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U. S. DEPARTMENT OF AGRICULTURE.

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B. T. GALLOWAY, *Chief of Bureau.*

FARM WATER SUPPLIES OF MINNESOTA.

BY

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IN COOPERATION WITH

The Minnesota State Board of Health.

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LETTER OF TRANSMITTAL.

U. S. Department of Agriculture,
Bureau of Plant Industry,
Office of the Chief,
Washington, D. C., May 10, 1909.

Sir: I have the honor to transmit herewith and to recommend for publication as Bulletin No. 154 of the series of this Bureau a paper entitled "Farm Water Supplies of Minnesota."

This paper was prepared by Mr. Karl F. Kellerman, Physiologist in Charge of Water Purification Investigations, and Mr. H. A. Whittaker, Scientific Assistant, with the informal cooperation of the Minnesota State Board of Health. The successful prosecution of this work has been due to the laboratory facilities and assistance kindly placed at our disposal by Dr. H. M. Bracken, Secretary of the Minnesota State Board of Health, and his colleagues Dr. F. F. Wesbrook, Director, and Dr. H. W. Hill, Assistant Director of the laboratories of the State Board of Health, to the skillful and conscientious technical work of Dr. A. J. Chesley in bacteriology and of Mr. M. G. Roberts in chemistry, and to the keen interest and appreciation displayed at all times by the Board as the investigations progressed.

Respectfully,
B. T. Galloway,
Chief of Bureau.

Hon. James Wilson,
Secretary of Agriculture.

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FARM WATER SUPPLIES OF MINNESOTA.

INTRODUCTION.

The chances of the dangerous pollution of a water supply increase as the surrounding or adjoining areas become more and more thickly settled, and, very naturally, the theories and methods of the sanitary control of water supplies have been developed in cities and from the standpoint of a congested population. It is becoming apparent, however, that even in this country, with its comparatively recent occupation and sparse rural settlement, both farm and city are suffering from the careless management of rural sanitation.

Two recent examples of this fact may serve more effectively to emphasize the moral that it is necessary to learn immediately whether dangerous sanitary conditions exist generally throughout the rural districts of the United States and to discover means of controlling or preventing such pollution. The first example is the prevalence of typhoid in the city of Washington, D. C., in spite of the fact that the water supply is filtered and of good character.[a] The inference seems clear that this unfortunate condition is due to the presence of typhoid cases on the farms supplying dairy and other products.

The second example is the report of the very high percentage of typhoid fever cases in some of the rural districts of Maryland, reaching two and one-half times the percentage found in Baltimore, the largest city in that State.[b]

While it is recognized that in only a limited percentage of cases can typhoid fever in rural districts be traced directly to the farm water, the condition of each supply fairly typifies the general conditions of hygiene and sanitation upon the respective farms. Evidently, then, the study of farm supplies involves many problems in addition to the examination of the water actually in use. A complete sanitary survey of some representative area of considerable extent with a thorough investigation of all the factors bearing upon each and all of the supplies is necessary before intelligent recommendations for improvement can be made. Unfortunately such studies[a] have not covered a sufficiently large area nor have a sufficient variety of methods been employed to meet these exacting requirements. Adequate knowledge of a single farm supply may require a study of the conditions of a rural home and its surroundings, and occasionally include the epidemiology of an entire neighborhood.

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[a] Rosenau, M. J., Lumsden, L. L., and Kastle, J. H. Report on the Origin and Prevalence of Typhoid Fever in the District of Columbia. Public Health and Marine Hospital Service, Hygienic Laboratory, Bul. 35. 1907.

Horton, T. The Prevalence and Causation of Typhoid Fever in Washington, D. C. Engineering News, vol. 56, No. 19, pp. 484–488. 1906.

Sedgwick, W. T. Comments upon Mr. Horton's Report and upon the Typhoid Fever Situation in the District of Columbia. Engineering News, vol. 56, No. 19, pp. 488–489. 1906.

The Causes of Typhoid Fever in the District of Columbia. Washington Medical Annals, vol. 7, pp. 33–122. 1908.

Magruder, G. Lloyd. Typhoid Fever in the District of Columbia. Washington Medical Annals, vol. 6, No. 1, pp. 69–71. Mar., 1907.

[b] Cited from Maryland Medical Journal by Dr. G. Lloyd Magruder. Washington Medical Annals, vol. 6, No. 1, March, 1907.

The scope of the investigations here presented is limited to a single State. This State, Minnesota, exhibits a wide range of rural conditions both from the economic point of view regarding mineral and agricultural resources and from the purely agronomic point of view regarding the variety of natural and cultural features incident to factors of climate, topography, geology, and relative age of settlement.

THE SELECTION OF SECTIONS FOR INVESTIGATION.

In the investigation of large sections of the country it is highly desirable to discriminate intelligently in the selection of the districts to be examined. The knowledge of the investigator preceding the investigation of a rural territory should include at least general information of the data available on its topography, geology, and hydrology.

The variation in these features makes possible the selection of certain typical sections which may fairly be compared with each other. It is, however, necessary at times to make examinations purely for epidemiological purposes even if this requires the duplication of certain lines of investigation.

The economic development of the territory is worthy of attention, and in interpreting data it must be kept constantly in mind, as it deals directly with the distribution of population, wealth, and resources.

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[a] The Water Supply. Oklahoma Agricultural Experiment Station, Bul. 66. 1905.

Miscellaneous Water Analyses. Oklahoma Agricultural Experiment Station, Bul. 67. 1905.

Palmer, A. W. Chemical Survey of the Water Supplies of Illinois. Report for the Years 1897–1902. University of Illinois. 1903.

Ladd, E. F. Waters of North Dakota. North Dakota Agricultural Experiment Station, Bul. 66. 1905.

Bartow, Edward. Chemical and Biological Survey of the Waters of Illinois. University of Illinois, Report for the Year Ending August 31, 1906, and Report, September 1, 1906, to December 31, 1907.

Dole, R. B., and Wesbrook, F. F. The Quality of Surface Waters in Minnesota. U. S. Geological Survey Bul., Water-Supply and Irrigation Paper No. 193. 1907.

The distribution of these factors has a marked influence upon the sanitary condition of any community, as well as upon the feasibility of urging expenditures when improvements are desirable. This is especially noticeable in the field of epidemiology when the investigator is dealing directly with the source and transmission of a disease.

TYPES OF FARM WATER SUPPLIES WITH REFERENCE TO FACTORS OF POLLUTION.

Farm water supplies can be divided into two fairly distinct classes—underground and surface. The underground supplies consist of dug wells, bored wells, drilled wells, driven wells, and springs; the surface supplies consist of rivers, lakes, surface reservoirs, and cisterns. In Minnesota the supply in most general use is perhaps the dug well, although the ratio of the different types varies with the location. Springs are used to a limited extent, usually in cases where their location is convenient. The use of surface supplies [a] varies with the locality and depends mainly upon the availability or character of the underground supply.

The dug well, probably the oldest type of well known, is usually a round or square excavation several square feet in area, the depth varying in different localities according to the distance of the water-bearing stratum from the surface of the earth. Its construction varies widely in different localities. The crudest form of a dug well consists of a shallow hole in the ground which collects water both from the surface and from the upper layers of the soil and has no covering to serve as a protection. Water from such a well is usually dipped, either directly or by means of a rope and bucket. In such a well no attempt whatever is made to protect the water from pollution. In the development of the deeper dug wells necessity demanded the use of a casing to hold back the soil, and various materials have been used for this purpose. In pioneer settlements logs are sometimes used, while in many regions boards are found. Modern casings [b] include a number of materials, such as stone, brick, cement, concrete, and tile, installed in various ways. Casings are now meant to serve as a protection from surface pollution in addition to holding back the soil; therefore, not only the use of suitable material but also the proper installation of that material is of the utmost importance.

Certain methods of drawing water from a dug well afford avenues for pollution of surface origin. The old style of drawing water by means of a chain or rope and bucket is undoubtedly a dangerous one; most of the wells equipped in this way are entirely uncovered, permitting the entrance of various kinds of organic and inorganic matter, and as the bucket on leaving the hands of the operator passes directly into the water an opportunity is given for polluting the well should the hands of the operator be infected. The ordinary type of iron pump is usually safe, although the so-called "priming" of pumps affords an opportunity for direct infection if the priming water or the vessel containing it is infected.

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[a] Dole, R. B., and Wesbrook, F. F., loc. cit.

[b] For antiquity of wells and casings, see J. G. Swindell and G. R. Burnell, Well-Sinking, pp. 1–5. London, 1886.

The covering of a dug well is also of great importance, and if tightly joined to the casing may prevent the entrance of surface pollution. Wood is used almost entirely for this purpose, but on account of the frequent wetting and drying to which most coverings are subjected, crevices soon form between the boards and foreign matter is admitted with the waste water from the pump. The covering of a well should be kept as dry as possible, and the surface immediately surrounding a well should slope away in all directions, in order to form a protection from surface water.

The bored well is used to a limited extent in various localities and is dug with machines made for that purpose. It differs from the dug well principally in size, the total area of the ordinary bored well being about one square foot. The casing used for this type of well is made of wood, tile, or tin. The tin casing used in certain sections is simply a soldered tin pipe extending the entire depth of the well. Long slender buckets with loose bottoms are used for drawing the water where the method of drawing is confined to the rope and bucket. The bored well is subject to practically the same criticisms of construction as the dug well. The area of surface exposed to external polluting influences is much smaller, yet it should be protected in the same careful manner recommended in the case of the dug well.

The drilled well, as the name signifies, is installed by means of a drilling apparatus. This type is usually found in sections where water is obtained only at a considerable depth and where the penetration of rock or some other hard stratum is necessary. The size of the shaft varies from about two inches to several feet.[a] The casing in some wells extends to the bottom and in others only to the rock formation, beyond which point the rock itself serves this purpose; the casing usually meets the base of the pump above the surface of the ground.

If a well pit has been excavated the casing extends only into that. In any case it should be tightly covered in order to prevent the entrance of surface pollution. Drilled wells very frequently have well pits which are about the size of a dug well and are from 8 to 12 feet in depth. Well pits 8 to 12 feet in depth and 3 to 4 feet in diameter are often sunk around the shaft for the purpose of protecting parts of the pumping apparatus from frost, and at times are a prominent factor in the pollution of a well, serving as catch basins for polluted water of recent surface origin. The depth of some wells is increased by driving or drilling. In these cases the dug portion really serves as a well pit and should be carefully protected against pollution.

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[a] Vernon-Harcourt, L. F. Sanitary Engineering, pp. 62–78. London, 1907.

The driven well, a type of supply first used at the beginning of the nineteenth century,[a] is usually found in localities where water is secured relatively near the surface. The casing consists of sections of iron pipe screwed into couplings so as to be continuous and water-tight throughout. The lower end of the pipe is armed with a sharp metallic point perforated with holes, which serves as a penetrating instrument during driving, and prevents the soil from entering the pipe. The iron pipe used for casing is usually about 2 inches in diameter, but varies in size from 1¼ to 10 inches.[b] Well pits are even more common with the driven than with the drilled well. In the driven well the shaft is usually not large enough to inclose the part of the pump which requires protection from frost, and a well pit is practically necessary with the ordinary type of iron pump. The driven well requires less care and is probably as safe as any type of moderately shallow supply.[c]

Springs are used to a limited extent as a source of farm water supply, their use depending mainly upon their convenience. A spring often may be made a safe supply by carefully protecting it against surface pollution, although in general the same factors influencing the safety of dug wells should receive consideration.

Cisterns are a very common form of farm water supply in certain localities where the underground water is hard to obtain or is unfit for use; historically they are perhaps the oldest form of artificial supply.[d] They are used for the storage of water from various sources, but usually for rain water. They may be constructed of brick and mortar, concrete, stone, etc., usually underground, or of galvanized iron, and placed wherever convenient. If well located and protected, the latter type should be satisfactory. The temptation is great, however, to locate this type on the surface, and in this case the temperature of the cistern water during the summer season is much higher than that in the underground type, and the growth of organisms, which are usually present in waters collected from roofs, is encouraged rather than discouraged. A roof which is the catchment area for cistern water may also collect anything carried in the air. The character of the materials deposited will of course depend upon the section of the country and the season of the year. Some of the most common are dust, dead insects, excreta from fowls of the air, seeds and spores of plants, and even vegetable growths. Sometimes a roof is constructed of material which can be partially extracted by rain water, and the solution thus formed becomes very objectionable at times, especially if the water collected is to be used for drinking purposes.

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[a] Olshausen, J. Schlagbrunnen. Gesundheits Ingenieur, 23. Jahrg., No. 17, pp. 278–280. 1900.

Sinking Driven Wells. Engineering Record, vol. 40, pp. 362–363. 1899.

Noyes, A. F. The Driven-Well System as a Source of or a Means of Obtaining a Water Supply. The Sanitary Engineer and Construction Record, vol. 16, pp. 264–265. 1887.

[b] Sinking Driven Wells. Engineering Record, vol. 40, pp. 362–363. 1899. See also Vernon-Harcourt, loc. cit., p. 48.

[c] Sutcliff, R. "Abyssinian" Tube Wells. Cited from Journal of Society of Arts by Van Nostrand's Engineering Magazine, vol. 23, pp. 281–285. 1880.

[d] Larousse, P. Citerne. Grand Dictionnaire Universel, vol. 4.

After the water enters the cistern proper the opportunities for pollution depend mainly upon the construction and protection of the type of cistern in use. Leaks probably offer one of the greatest opportunities for pollution if the cisterns are located beneath the surface; in this case ground water is often given free entrance. Ground water in the neighborhood of cisterns is not infrequently polluted, for in its passage through the small amount of surface soil usually covering a cistern very little purification is effected. Priming is usually necessary in cistern pumps, and when water-borne diseases are present in the home this practice may prove a very dangerous factor in the transmission of disease. The quality of cistern water can be much improved by installing a device for turning away the water caught during the first part of a shower; this secures a thorough washing of the roof before any water enters the cistern.

Surface reservoirs are built in certain farming sections[a] for collecting and holding surface water. The construction of the ordinary type is very simple. A portion of the surface soil is removed, which leaves a depression for collecting water from a small natural or artificial catchment area. These reservoirs are usually located in a more or less impervious soil, although clay is sometimes used to line a reservoir which would not otherwise hold water. Water for domestic purposes is either dipped or pumped from these reservoirs. When pumps are used they are suspended on a platform built over the water which is connected with the shore by a board walk. The purity of such a supply depends mainly upon the protection of the area from which the supply is collected; the season will also influence the condition of the water, depending upon the temperature, rain, snow, wind, and other atmospheric conditions.

Rivers and lakes are used to a very limited extent as a source of drinking water for farms in Minnesota. Their potability depends almost entirely upon the environment of the individual lake or river in question. The pollution includes principally waste material contributed by thickly populated communities. In rural communities rivers and lakes are used more extensively during the winter season, the temperature at that time making the water more palatable, although probably no less dangerous.

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[a] In Kittson County, Minn., this practice is common.

METHODS OF COLLECTION AND EXAMINATION OF WATER SUPPLIES.

The selection of farms for illustrating various conditions of rural sanitation is best made by actual observation and from information secured in the field. If possible, several types of water supplies are chosen in each community, though these selections are of course influenced by the sanitary environment of the different types, more time being given to the investigation of unsatisfactory conditions. The data secured in the present investigation and recorded in the field are grouped under three general headings: (1) Identification data; (2) general and structural water data; and (3) general sanitary and epidemiological data. The laboratory determinations are reported in Table IV, pages 78 and 79.

The identification data for various reasons have been sufficiently abridged so that only the general location of the farms under discussion can be determined.

The general sanitary and epidemiological data may be of direct or indirect interest in reference to the water supply, but in either case include a concise statement of the apparent character of the supply. This statement may or may not uphold the results of the analysis of the samples of water collected, but is essential for interpreting correctly the chemical and bacteriological data.

The collection of field data and samples of water was made by Mr. H. A. Whittaker, representative of the Bureau of Plant Industry. Both chemical and bacteriological samples were taken from each supply investigated and were shipped immediately to the laboratories of the Minnesota State Board of Health for examination. The chemical and physical analyses were made partly by Mr. M. G. Roberts, of the State Board of Health, and partly by Mr. Whittaker, in accordance with the recommendations of the committee on standard methods of water analysis of the American Public Health Association. The bacteriological counts and the tests for *Bacillus coli* were made by Dr. A. J. Chesley, of the State Board of Health laboratories. The method used in examination followed the recommendations of the committee mentioned, with the following exceptions:

(1) Agar was used instead of gelatin for counts.

(2) Incubation was at room temperature and for four days from time of plating. If less than four days were established as a limit, plates would often be received in the laboratory so long after plating that the allowed incubation period would already have been exhausted in transit.

(3) The colon tests recommended alternatively as procedure A and procedure B by the committee on standard methods of water analysis of the American Public Health Association were both employed, the former on 100 c. c. samples enriched by quadruple strength broth and incubated; the latter on 1 c. c. samples prepared in the field, which is also an enrichment method.[a]

(4) The preparation of media followed strictly the committee's recommendations except in the following details:

Plain nutrient broth. Sterilized in an autoclave.

Dextrose broth. The muscle sugar removed.

Milk. Owing to variability of ordinary milk the following substitute was used: Nutrose (sodium-phosphate-casein) 2.6 grams, lactose 1 gram, distilled water 100 c. c. Heat to dissolve casein, but *do not boil;* filter, tube, and autoclave fifteen minutes at 15 pounds.

Potato. Not prescribed by the committee. This is prepared by cutting diagonal half cylinders from good fresh potatoes and washing over night to remove acidity. The half cylinders were dropped large end down into test tubes containing wet cotton at the bottom. The potato tubes were autoclaved.

The order of procedure in the adjustment of acidity in nutrient agar and gelatin media was slightly changed.[b]

(5) From all the dilutions made those plates were selected which yielded counts of not much above 200, all that were higher or lower being disregarded. If deep well waters or other waters normally showed counts below 40 to each cubic centimeter, several plates were made and the results averaged.

The traveling laboratory case designed by Dr. H. W. Hill, Assistant Director of the Minnesota State Board of Health Laboratories, as an improvement on the field outfit formerly in use for sanitary studies of water supplies, is very complete and satisfactory for work of this character, and at our request Doctor Hill has furnished the following description:

The traveling laboratory case is a box made of half-inch pine, 18¼ inches long, 6¾ inches wide, and 16¾ inches high, outside dimensions. The front opens on strap hinges at the base. The top is supplied with a comfortable handle and opens on strap hinges at the back; it carries a hinged iron strap, which engages with a staple on the front and is secured with a padlock. The box is treated inside and out with anilin black, and the corners are protected by trunk shoulder plates.

A half-inch horizontal partition divides the box into two sets of compartments. The lower set consists of three compartments 8 inches high and 6 inches deep; two of these, adjoining, are 5 inches wide; the third is 6¼ inches wide. The 5-inch compartments each carry ten Petri dishes, which are wrapped in filter paper before sterilization to exclude dust and to prevent breakage in transit. The third compartment carries a Barthel alcohol lamp, and inverted over the lamp is a copper dish (4 inches in diameter, 5 inches high), for boiling water to melt agar media, and a tripod for supporting the dish on the stem of the lamp. A small bottle for extra alcohol and one or two towels also fit into this compartment. The upper set consists of one large compartment 6 inches deep, 7 inches high, and 10½ inches wide, and a small one 6 inches deep, 7 inches high, and 6¼ inches wide. The small compartment carries six cylindrical 4-ounce glass-stoppered collecting bottles and two rectangular 5-ounce rubber-stoppered bottles for sterile dilution water. The large compartment contains two wooden test-tube racks, supported by vertical guides at the ends, and constructed of ¼-inch pine as follows: From the center line of a flat wooden base (1½ inches wide and 10 inches long) rises a flat sheet of wood (5 inches high and 10½ inches long); narrow vertical strips of wood at each end of each side of this sheet coapt with the vertical guides on the ends of the compartment, leaving a narrow edge of the ends of the sheet exposed to slide in the slots of the guides. Two pins in each vertical strip permit rubber bands to be stretched across each side of each sheet from end to end. The test tubes are inserted between the sheet and the rubber bands on each side of the sheet, resting on the wooden base. Each rack carries about twenty test tubes. The floor of this compartment next to the back of the box is cut away along its whole length for a width of 1⅛ inches; through this opening pass pipette cases containing two thermometers and about twenty pipettes, four pipettes to a case. Between the racks is space for an envelope containing gummed labels, spare elastics, a lead pencil, a glass pencil, etc., and cards for recording data on samples collected.

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[a] Wesbrook, F. F. Laboratory Methods and Devices. Journal of Infectious Diseases, Supplement No. 1, pp. 322–323. 1905.

[b] Hill, H. W. Suggestions for Changes in the Schedules for Making Broth, Gelatin, and Agar, etc. Journal of Infectious Diseases, Supplement No. 2, pp. 223–225. Feb., 1906.

APPARATUS.

Petri dishes.—Twenty to twenty-two standard 4-inch dishes with porous tops.

Test tubes.—Forty to forty-five standard 6-inch by ⅝-inch tubes; twenty to twenty-two containing 10 c. c. each of standard agar for plating, the remainder plugged and sterilized but empty, for making dilutions, etc.

Pipettes.—Six cases of four 1 c. c. pipettes each; one case containing 5 c. c. pipettes.

DESCRIPTION OF THE WATER SUPPLIES EXAMINED.

In the course of the present investigation 28 dug wells, 6 bored wells, 13 drilled wells, 19 driven wells, 2 springs, 1 river,[a] 2 surface reservoirs, and 5 cisterns were examined. A brief statement of the sanitary condition of each supply is made, based partly upon the data secured from the chemical and bacteriological studies of water samples and partly upon the conditions shown by the sanitary inspection of the environment of the various supplies.

The identification of supplies as either good or polluted can be made only by laboratory investigations upon properly collected fresh samples of the water, together with a personal inspection by a trained expert of the environment of the supply.

Further explanation is perhaps desirable regarding the use of the terms "good" and "polluted" in the following descriptions of the various water supplies. A water supply to be described as good must be so located that the apparent possibilities of dangerous pollution are remote, and the samples of water taken for laboratory study must conform to the definition[b] of a pure and wholesome water:

> Unquestionably the term "pure and wholesome water" as ordinarily used relates to water intended to be used for drinking. Such a water must be free from all poisonous substances, as the salts of lead; it must be free from bacteria or other organisms

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[a] The Red Lake River, on which four of the supplies examined were located.

[b] Whipple, George C. The Value of Pure Water, pp. 3–4. New York, 1907.

liable to cause disease, such as the bacilli of typhoid fever or dysentery; it must also be free from bacteria of fecal origin, such as *B. coli.* In other words, the water must be free from poisonous substances, from infection, and even from contamination. By this term is meant pollution with fecal matter. Contamination must be considered as potential infection. Besides this, it must be practically clear, colorless, odorless, and reasonably free from objectionable chemical salts in solution and from microscopic organisms in suspension. Moreover, it must be well aerated. Color, turbidity, odor, dissolved salts, etc., may be permissible to a small degree without throwing the water outside of the definition of pure and wholesome waters. In these minor matters local standards govern up to a certain point, and it is in regard to them that differences in judgment and experience of analysts lead to diverse classifications.

Dug well No. 7 illustrates these conditions. The environment of the well appears reasonably safe even though it is not entirely satisfactory, and the analytical data secured from the water samples indicate a good water both chemically and bacteriologically. Dug well No. 10 shows the opposite conditions; the environment is very unsatisfactory, and the laboratory studies show that the water is polluted.

In the following descriptions of the sanitary condition of the water supplies examined upon various farms, the location of the farms, for obvious reasons, is shown only in an approximate way. Arrows are used in the accompanying sketches to show the slope of the ground.

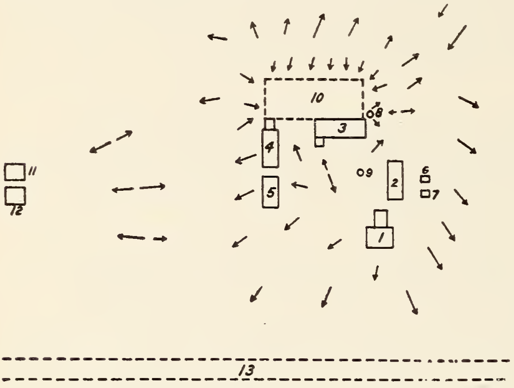

FIG. 1.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 1: 1, Farmhouse; 2, stone house; 3, hay barn with basement; 4, chicken house; 5, granary; 6, storehouse; 7, privy; 8, dug well; 9, drilled well; 10, barnyard; 11, hay barn; 12, hay barn; 13, public road.

DUG WELLS.

No. 1. A polluted supply. The dug well should be abandoned and water taken from the drilled well.

Location of farm.—Merriam Park, Minn.

Date of visit.—July 3, 1908.

Size.—Eighty acres.

Kind of farming.—General.

Topography.—In general, slope of ground is away from house and from most of the outbuildings. The barnyard slopes in the direction of the basement stable.

Source of water supply.—(See fig. 1.) The well in use is adjacent to the stable and barnyard; 28 feet in depth; casing, brick. The unused well, which is of the drilled type, is located midway between the house and stable, 140 feet deep, with a 3-inch iron casing well protected at surface. *Strata*: Dug well (No. 8), 23 feet surface clay and 5 feet sand; drilled well (No. 9), 130 feet surface clay and hardpan, 5 feet rock, and 5 feet gravel. *Yield*: Dug well, abundant during wet season; drilled well, abundant at all seasons. *Use*: Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Dug well (No. 8) is only 15 feet from barnyard; however, surface of well is raised about 5 feet above level of yard. The barnyard unfortunately has no drain, and the surface of the yard is covered with a saturated mixture of water and manure most of the year. The danger to the shallow well is increased from the fact that the supply at times is scarcely adequate. The possibilities of polluting the drilled well (No. 9) from its surroundings are limited on account of its depth and surface protection. This well would undoubtedly make the safest supply, but as more effort is required to pump the water from a depth of 140 feet and because of the added objection of a slight iron taste, it has been almost entirely abandoned; it is now used only in case the supply in the dug well is insufficient.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; privy poor, unprotected vault.

Milk.—Used on farm. Sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 2. A polluted supply. It would be impracticable to attempt to obtain a potable supply from this well.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 8, 1908.

Size.—Thirty-six acres.

Kind of farming.—Dairy.

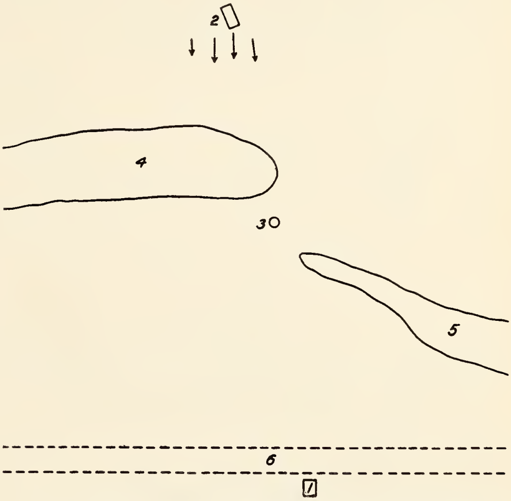

FIG. 2.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 2: 1, House; 2, barn and stables; 3, well; 4, pond; 5, pond; 6, street.

Topography.—The well is in the center of a marshy field about 20 rods from the house and barn. The barn is on dry land elevated several feet above the marsh. The slope from the house to the well is very gradual.

Source of water supply.—(See fig. 2.) The well is in the center of a marshy field surrounded by ponds; 15 feet in depth; casing, wood. *Strata:* Soft marsh soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* The well is probably in the poorest location possible to select, and its mouth has little protection from surface washings. Cattle make the well a resting place and considerable manure is deposited about the well ready to be carried in by surface washings.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds adjacent to well. The surface of these ponds is partly covered with a green growth, the odor from which would indicate very stagnant water. Some of the water in these ponds undoubtedly finds its way into the well.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; manure is thrown out on two sides of the stable and the leachings flow back under the stable floor; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 3. A slightly polluted supply. This pollution could be avoided by installing a good casing and a tight covering.

Location of farm.—St. Paul, Minn.

Date of visit.—July 16, 1908.

Size.—Twelve acres; 2 owned and 10 rented.

Kind of farming.—Dairy.

Topography.—The house is located on the highest ground, the elevation being about 5 feet above the well and outbuildings.

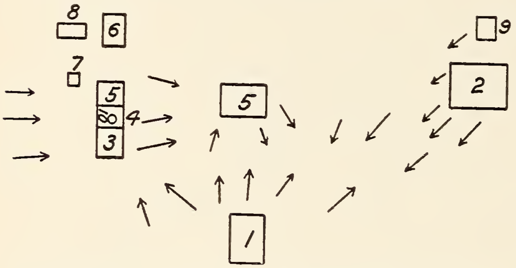

FIG. 3.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 3: 1, House; 2, stables; 3, wagon shed; 4, pump house; 5, tool shed; 6, ice house; 7, privy; 8, hogpen; 9, chicken house; 10, well.

Source of water supply.—(See fig. 3.) The well is in a protecting shed; 80 feet in depth; casing, 1½-inch planks; area of well, 3 square feet. *Strata:* Unknown. *Yield:* Abundant. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Poor. The casing near the surface is loose and affords opportunity for entrance of surface water. The well cover appeared very unclean, as the pump house had been used for sheltering chickens.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables fair; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—The owner of the farm had a severe case of typhoid two years previous to the date of visit. He was accustomed to visit the city of St. Paul daily. The entire family drank this well water at the time, but no others became infected. It would seem reasonable to suppose that the fever was contracted elsewhere than on the farm.

Analyses.—See page 78.

No. 4. A polluted supply. This supply could be very much improved by the installation of proper casing, covering, and pump.

Location of farm.—St. Paul, Minn.

Date of visit.—July 16, 1908.

Size.—One hundred and forty acres.

Kind of farming.—General.

Topography.—The general slope of the ground is away from the house in the direction of the stables. The house is 3 feet above the mouth of the well and about 8 feet above the outbuildings, and a pond is on a still higher elevation.

Source of water supply.—(See fig. 4.) The well is about 20 feet from the house and 30 feet from a marshy pond; 38 feet in depth, 3 feet square; casing, 1½-inch wood planks. *Strata:* Clay, 28 feet, and sandy gravel, 10 feet. *Yield:* Abundant in summer, but scanty during the winter. This would seem to indicate that the well was drawing from the pond, as this source of supply would be cut off during the winter. *Use:* Drinking and general farm purposes. *Method of lifting:* Old-fashioned bucket, pulley, and rope. *Sanitary aspect:* The well is dangerously located. The house is only 21 feet away and on a higher level; a stagnant marshy pond is within 30 feet on a higher level; the unprotected privy vault is on the same level and within 35 feet. The mouth of the well is protected only with the usual slant-roof covering of bucket wells. At high-water periods the pond overflows and forms a stream not 15 feet from the well. The casing does not extend above the surface of the ground.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A marshy pond filled with stagnant water during the entire year.

Sanitary condition of farmhouse and outbuildings.—Very poor in every way.

Milk.—Used on farm; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 5. A slightly polluted supply. The character of the water could undoubtedly be improved by better surface protection.

Location of farm.—St. Paul, Minn.

Date of visit.—July 17, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

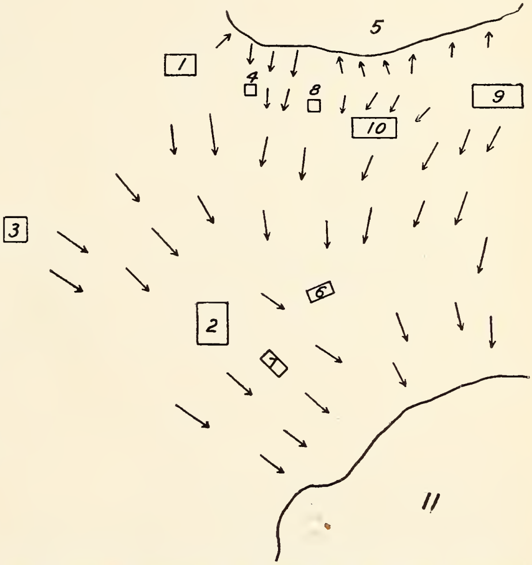

FIG. 4.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 4: 1, House; 2, stables; 3, granary; 4, well; 5, pond; 6, chicken house; 7, chicken house; 8, privy; 9, hogpen; 10, cow stable; 11, pond.

Topography.—The ground slopes away from the house in all directions. The house is 3 feet above the barn and 14 feet above the well. The slope from north to south is quite gradual at first and then becomes very abrupt.

Source of water supply.—(See fig. 5.) The well is 200 feet from the stables and approximately 400 feet from the house. It was originally an ordinary dug well, but later a 12-inch tile casing was placed down the entire depth of the well and stones of various size filled around it The well is 25 feet deep. *Strata:* Clay entire depth. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Ordinary wooden pump with wooden pipe extending to the bottom of the well. *Sanitary aspect:* Fair. The tile casing extends above the surface, but does not exclude the danger of seepage through the loose stone filling surrounding the tile. *Abandoned well:* A well (No. 9) 160 feet deep was abandoned some years ago on account of a bad odor, excessive iron, and extreme hardness of the water.

Cisterns: One, used for drinking and washing purposes; contains a filter wall and appears to be in good condition.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House in exceptionally good condition; stables well cared for; privy poor; unprotected vault.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—No record of any having occurred in recent years.

Analyses.—See page 78.

No. 6. Probably a polluted water, although the bacteriological data are lacking. This supply could undoubtedly be made safe by installing a pump, extending the casing above the surface, and banking and trenching to protect from surface pollution.

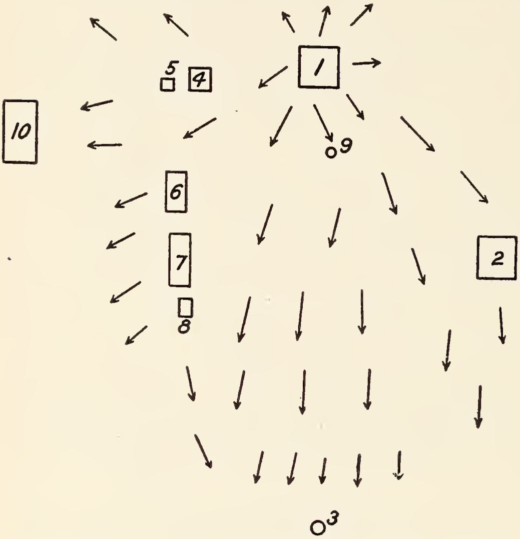

FIG. 5.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 5: 1, House; 2, barn; 3, well; 4, ice house; 5, privy; 6, wagon shed; 7, granary; 8, chicken coop; 9, abandoned well; 10, hay barn.

Location of farm.—Gladstone, Minn.

Date of visit.—July 20, 1908.

Size.—Thirteen acres.

Kind of farming.—General.

Topography.—The slope of the ground is generally in one direction; the total fall between privy and stable, a distance of about 150 feet, is about 10 feet.

Source of water supply.—(See fig. 6.) The well is midway between the house and the stables; 22 feet deep, wooden casing. *Strata:* Clay, 9 feet, and sand, 13 feet. *Yield.*—Abundant. *Use:* Drinking and general farm purposes. *Method of lifting.*—Rope and bucket. *Sanitary aspect:* Bad; no protection whatever has been provided against surface wash and the well seems to be in bad condition.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One small lake; also a creek leading into lake.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy poor, unprotected vault.

Milk.—None.

Water-borne diseases.—One case of typhoid thirteen years ago, at which time a different water supply was used.

Analyses.—See page 78.

No. 7. A good water. The mouth of the well should be protected from surface wash, and a good casing and covering should be installed. In its present condition the supply is in danger of pollution.

Location of farm.—Gladstone, Minn.

Date of visit.—July 18, 1908.

Size.—Seventy-five acres.

Kind of farming.—Dairy.

Topography.—The slope of the ground is away from the house in all directions. The well is 3 feet lower than the house, and the stables are about 5 feet lower than the well.

Source of water supply.—(See fig. 7.) The well is covered by the pump house; 20 feet in depth; casing, ordinary 1½-inch planks. *Strata:* Gravel and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Ordinary iron pump; windmill used for power. *Sanitary aspect:* Fair. The location is slightly below that of the surrounding ground and the mouth of the well has no protection from surface wash. Slop from the milk house is thrown on the ground near the well and undoubtedly finds its way into the well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several small ponds; one small marshy pond about 20 rods back of house.

Sanitary condition of farmhouse and outbuildings.—House good; milk house fair; stables poor; privy poor, unprotected vault.

Milk.—Retailed in St. Paul; sanitary care fair.

Water-borne diseases.—No record of any for the past three years.

Analyses.—See page 78.

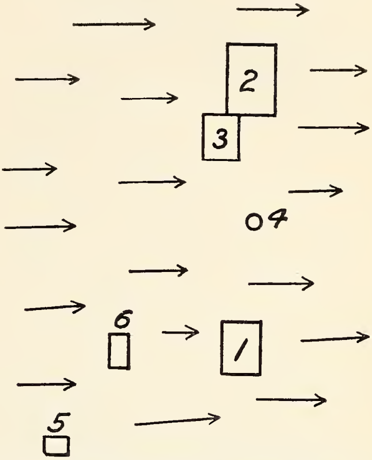

FIG. 6.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 6: 1, House; 2, barn and stables; 3, wagon shed; 4, well; 5, privy; 6, woodshed.

No. 8. A polluted supply. It is possible that this supply could be protected from pollution if a tight casing was installed; however, owing to the dangerous location and shallow depth of the well this is doubtful.

Location of farm.—Hastings, Minn.

Date of visit.—July 22, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—General.

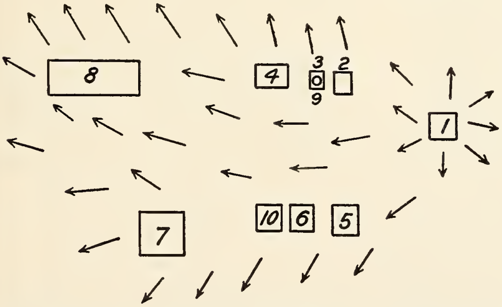

FIG. 7.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 7: 1, House; 2, milk house; 3, pump house; 4, wagon shed; 5, tool shed; 6, ice house; 7, horse barn; 8, cow stable; 9, well; 10, wagon shed.

Topography.—The surface slopes from the house in the direction of the well and outbuildings.

Source of water supply.—(See fig. 8.) The well is about 15 feet from the barnyard on low ground; 18 feet deep; casing, uncemented stone. *Strata:* Gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; well too near the barnyard. The surface is well protected with tightly matched heavy planks. The mouth of the well is raised about 6 inches above the cement floor of the pump house.

Cisterns.—Used for washing only.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—Exceptionally good.

Milk.—Skimmed milk used on farm; cream shipped to St. Paul; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 9. The cistern supply is polluted. The well is satisfactory and should be used for direct supply where water of good sanitary quality is needed.

Location of farm.—Hastings, Minn.

Date of visit. July 22, 1908.

Size.—Forty acres.

Kind of farming.—Dairy and general.

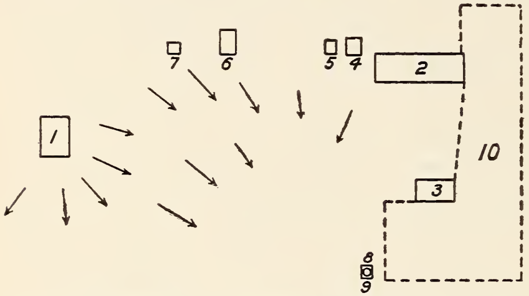

FIG. 8.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 8: 1, House; 2, stables; 3, stone house; 4, granary; 5, corncrib; 6, ice house; 7, privy; 8, pump and milk house; 9, well; 10, barnyard.

Topography.—The house is about 35 feet from the well and about 3 feet higher; the general slope is in the direction of the outbuildings.

Source of water supply.—(See fig. 9.) The well is 35 feet from the house and 20 feet from the stables; after digging the well a 6-inch tile casing was installed and the well filled; 127 feet in depth. *Strata:* Mixture of sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill used for power. *Sanitary aspect:* Well fair; cistern poor.

Cisterns.—Well cistern located at corner of stable about 15 feet from the well; circular, with flat bottom and arched top, cement bottom, sides, and top; capacity, 75 barrels. The water is pumped from the well into the cistern as a reserve supply in case the windmill fails to pump. Almost the entire supply, drinking included, is used from this cistern. An ordinary iron hand pump is used to draw water.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—Good.

Milk.—Retailed in city; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

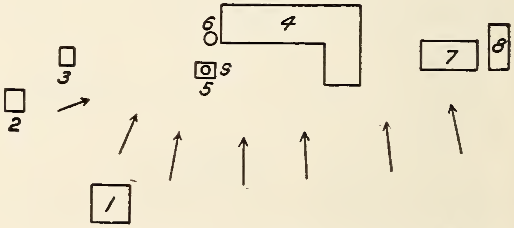

FIG. 9.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 9: 1, House; 2, ice house; 3, privy; 4, stables; 5, milk and pump house; 6, cistern well; 7, chicken coop; 8, hogpen; 9, well.

No. 10. A polluted supply. The well should be condemned for domestic use and another sunk in a more suitable place.

Location of farm.—Red Wing, Minn.

Date of visit.—July 23, 1908.

Size.—One hundred and three and one-half acres.

Kind of farming.—Dairy.

Topography.—The entire drainage from all the buildings and the barnyard reaches the well, which is about 12 feet below the highest point of the yard.

Source of water supply.—(See fig. 10.) Well at corner of barnyard; 15 feet in depth; casing, uncemented stone. *Strata:* Ordinary black marshy soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, though on date of visit the pump was out of order and the water was drawn with a rope and tin pail. *Sanitary aspect:* Bad; surface wash from the entire barnyard and stables has ample opportunity for reaching the well in case of heavy rain. The unprotected privy vault is located above the well. The ground surrounding the well is marshy and is flooded during the spring season of the year.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Many springs in the marshy section on which the well is located. Hay Creek, a small stream, flows through the marsh 10 to 15 rods from the well.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

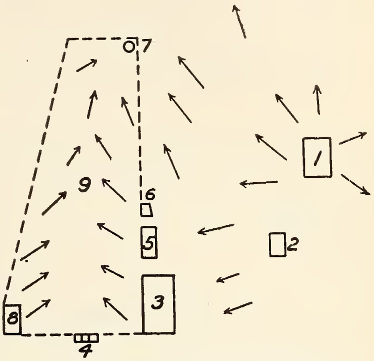

FIG. 10.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 10: 1, House; 2, wood shed; 3, barn and stables; 4, bridge; 5, milk house and corncrib; 6, privy; 7, well; 8, hogpen; 9, barnyard.

No. 11. A polluted supply. This well might furnish a good supply if great care was taken in protecting it from both surface and underground pollution by installing a proper casing and a tight covering.

Location of farm.—Red Wing, Minn.

Date of visit.—July 24, 1908.

Size.—Three acres.

Kind of farming.—General.

Topography.—Level of well about 1 foot below that of house.

Source of water supply.—(See fig. 11.) Well about 30 feet from the house; 10 feet in depth; no casing. *Strata:* Surface soil and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The mouth of the well is practically unprotected and can receive polluted surface drainage.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables good; privy poor, unprotected vault.

Milk.—Used on farm; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

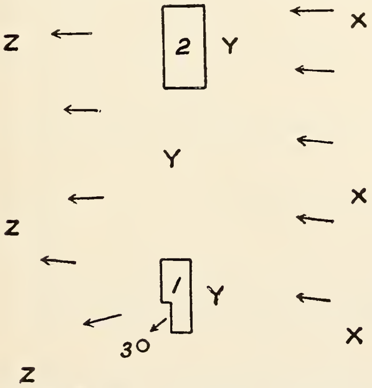

FIG. 11.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 11: 1, House; 2, barn; 3, well. X, High ground; Y, intermediate; Z, low ground.

No. 12. A polluted supply. It is very doubtful whether this supply could be made a safe one.

Location of farm.—Mankato, Minn.

Date of visit.—July 28, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—Dairy and general.

Topography.—Low level ground in the Minnesota River Valley.

Source of water supply.—(See fig. 12.) Well at the side of the house porch; 25 feet in depth; casing, uncemented stone. *Strata:* Sand, clay, and gravel, more or less mixed. *Yield:* Abundant. *Use:* Drinking and house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad; polluted from upper strata and also from surface wash. About July 1 the house cellar filled with surface water and the well water could not be used on account of its disagreeable taste and odor. Covering of well in good condition but on a level with surrounding ground.

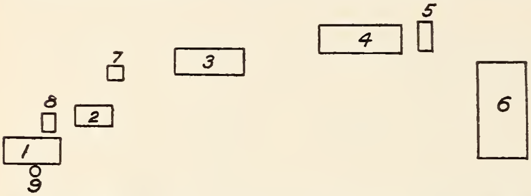

Fig. 12.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 12: 1, House; 2, ice house; 3, tool shed; 4, tool shed; 5, chicken house; 6, barn and basement stables; 7, privy; 8, milk house; 9, well.

Cisterns.—One, used for washing only.

Lakes, rivers, ponds, and springs.—Ponds during wet season. One spring, used for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House very good; stables very good; milk house good; privy poor, open vault and unprotected.

Milk.—Retailed in city; sanitary care good.

Water-borne diseases.—One case of typhoid. A boy, aged 15 years, taken ill July 18; doctor called July 19 and pronounced the case typhoid; temperature 101°. This boy drank water in Mankato on July 5 and 12, which was during the course of a severe typhoid epidemic. From the dates of other cases in Mankato and from the fact that the trouble in that city is laid to the city water, which the boy drank, it is reasonable to assume this as the source of infection.

Analyses.—See page 78.

No. 13. A polluted supply. By proper grading and draining and by installing a good casing and tight covering this supply could be made safe.

Location of farm.—Mankato, Minn.

Date of visit.—July 28, 1908.

Size.—Twenty-eight acres.

Kind of farming.—Dairy.

Topography.—The surface surrounding the house and outbuildings is generally level, although several slight depressions hold surface water during the wet season.

Source of water supply.—(See fig. 13.) Well about 25 feet from house; 12 feet in depth; casing, uncemented stone. *Strata:* Blue clay, 8 feet, and gravel, 4 feet. *Yield:* During dry season supply is uncertain. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Well receives surface wash from entire house and barnyard. Covering poor and allows back flow of water from pump. Privy, with old open vault, 25 feet from well. Pond polluted with algæ is located some 25 feet from the well and at about the same level.

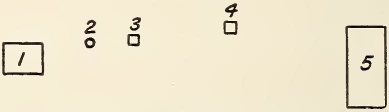

Fig. 13.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 13: 1, House; 2, well; 3, tool shed; 4, privy; 5, barn and stable.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds during wet season.

Sanitary condition of farmhouse and outbuildings.—House fair; stables very poor; privy poor.

Milk.—Retailed in city; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 14. A good supply, although it may become polluted by drainage from the upper strata.

Location of farm.—Mankato, Minn.
Date of visit.—July 28, 1908.
Size.—Sixty-five acres.
Kind of farming.—Dairy.
Topography.—House and outbuildings on level ground.
Source of water supply.—(See fig. 14.) Well about midway between house and stables; 27 feet in depth; casing, uncemented stone. *Strata*: Surface soil and blue clay. *Yield*: Abundant except during a very dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good, although well is too near barnyard. Mouth of well slightly raised and well covered.
Cisterns.—One, used only for washing.
Lakes, rivers, ponds, and springs.—Ponds during wet seasons.
Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house good; privy fair.
Milk.—Retailed in city of Mankato; sanitary care good.
Water-borne diseases.—None recorded.
Analyses.—See page 78.

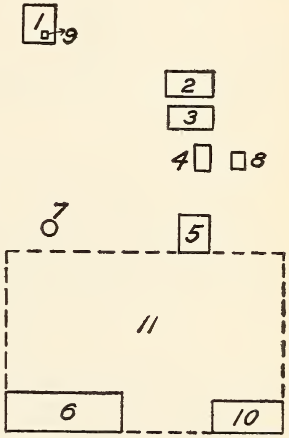

Fig. 14.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 14: 1, House; 2, smokehouse; 3, tool shop; 4, corncrib; 5, granary; 6, barn and stables; 7, well; 8, hogpen; 9, cistern; 10, barn and stables; 11, barnyard.

No. 15. The house supply is polluted, a condition which could be remedied by installing a good casing and a tight covering.

Location of farm.—Owatonna, Minn.
Date of visit.—July 30, 1908.
Size.—Two hundred acres.
Kind of farming.—Dairy and general.
Topography.—House and barn about 2 feet higher than intervening land.
Source of water supply.—(See fig. 15.) House supply (No. 2) under house porch; 40 feet in depth; casing, stone. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Poor. The well receives surface wash at times of excessive rain. The open-vault privy is located some 40 feet away, which makes the location of the well more unsuitable. Stable supply (No. 9) near stables; 40 feet in depth; casing, wood. *Strata:* Sand, 15½ feet, and blue clay, 24½ feet. In this case a vein of water was found in the blue clay which is not characteristic for this locality. *Yield:* Abundant. *Use:* Farm purposes and at times for drinking. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Fair; near the stables but reasonably well protected.
Cisterns.—One, used for washing.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House excellent; barn and stables excellent; privy poor.
Milk.—Sold to creamery; sanitary care excellent.
Water-borne diseases.—None recorded.
Analyses.—See page 78.

No. 16. A polluted supply. By draining the barnyard and outbuildings in another direction, which is possible in this case, and by installing a tight casing and covering this supply could be made satisfactory.

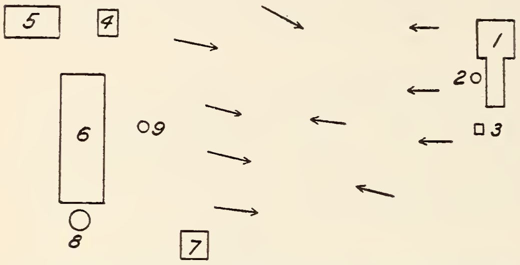

FIG. 15.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 15: 1, House; 2, well; 3, privy; 4, granary; 5, wagon shed; 6, barn and stables; 7, chicken house; 8, silo; 9, well.

Location of farm.—Owatonna, Minn.

Date of visit.—July 30, 1908.

Size.—One hundred and thirty-six acres.

Kind of farming.—General.

Topography.—Surface generally level, but barnyard slopes quite abruptly toward the well; about 8 feet difference in elevation between well and surrounding higher ground.

Source of water supply.—(See fig. 16.) Well in barnyard about 35 feet from stables; 30 feet in depth; casing, uncemented stone. *Strata:* Unknown; judging from other wells in locality, blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill used for power. *Sanitary aspect:* Very bad. The entire drainage of the barnyard flows toward the well; puddles surround the well; the mouth is slightly raised but at times surface wash enters.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables and barnyard poor; privy very poor, open vault.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 17. A polluted supply. This supply could be made satisfactory by installing a good casing and a tight covering and by trenching and banking the soil around the mouth of the well to turn the flow of surface water in the opposite direction.

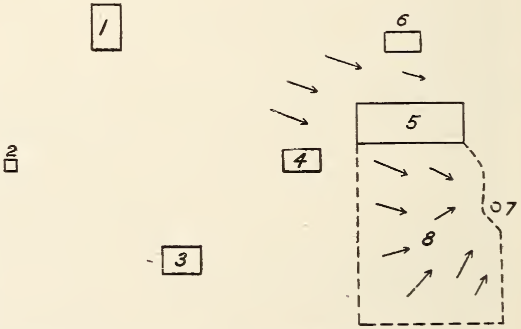

FIG. 16.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 16: 1, House; 2, privy; 3, granary; 4, tool shed; 5, barn and stables; 6, corncrib; 7, well; 8, barnyard.

Location of farm.—Austin, Minn.

Date of visit.—August 1, 1908.

Size.—Six hundred and forty acres.

Kind of farming.—General.

Topography.—Surface level around house and outbuildings.

Source of water supply.—(See fig. 17.) Well very near stables and surrounded by farm buildings; 60 feet in depth; casing, tile. *Strata:* Yellow clay. *Yield:* Abundant.

Use: Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Bad. During heavy rains so much surface water enters that well can not be used for several days.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House excellent; stables good; milk-house fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

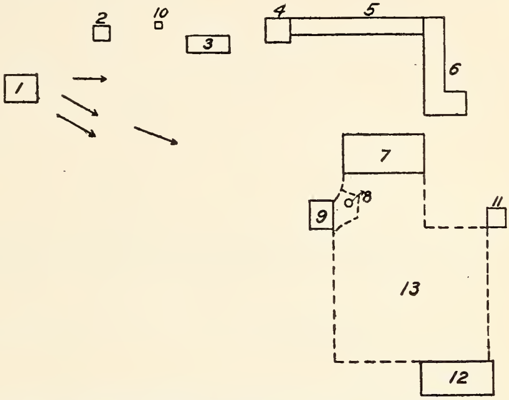

FIG. 17.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 17: 1, House; 2, wood shed; 3, corncrib; 4, granary; 5, wagon shed; 6, chicken house; 7, barn and stables; 8, well; 9, ice house; 10, privy; 11, tool shed; 12, stables; 13, barnyard.

No. 18. A polluted supply. This well could unquestionably be made a safe supply by improving the construction of the casing and covering.

Location of farm.—Austin, Minn.

Date of visit.—August 1, 1908.

Size.—Eighty acres.

Kind of farming.—General.

Topography.—House about 2½ feet above stables; well on same level as house.

Source of water supply.—(See fig. 18.) Well about halfway between house and stables; 28 feet in depth; 3 feet square; casing, wood. *Strata:* Surface soil, 2 feet; sand, 8 feet; hardpan, 4 feet; sand, 6 feet, and rock, 8 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Surface covered with loose boards; surface water at times undoubtedly enters; surface drainage away from well except during heavy rains.

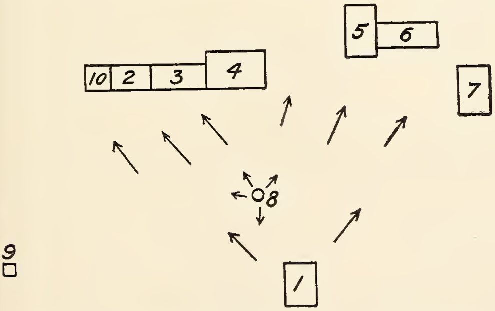

FIG. 18.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 18: 1, House; 2, milk house; 3, cow stable; 4, barn and stables; 5, corncrib; 6, hogpen; 7, granary; 8, well; 9, privy; 10, wood shed.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stable very poor; privy very poor, open vault, very poorly protected and shows no attention whatever.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 19. A polluted supply. The polluting environment should be removed or a well dug in a better location. In either case a proper covering and a good pump should be installed.

Location of farm.—Oakland, Minn.

Date of visit.—August 1, 1908.

Size.—Seventy acres.

Kind of farming.—General.

Topography.—The surface surrounding house has been artificially raised about 1 foot above outbuildings; well is on same level as stables and barnyard.

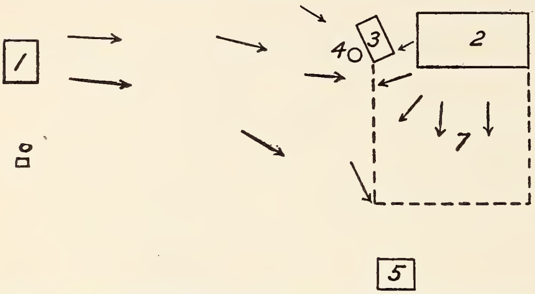

Fig. 19.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 19: 1, House; 2, stable and barn; 3, tool shed; 4, well; 5, wagon shed; 6, privy; 7, barnyard.

Source of water supply.—(See fig. 19.) Well several feet from barnyard and stables; 12 feet in depth; casing, 2-foot tile. *Strata:* Black loam, 2 feet; gravel, blue clay, and quicksand at bottom. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad, due to the filthy barnyard about 10 feet away. Surface wash is prevented by a 1-foot extension of tile.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy very poor, uncared for, open vault.

Milk.—Sold to creamery; sanitary care very poor.

Water-borne diseases.—One case of typhoid in October, 1901; several cases were in the neighborhood about the same time.

Analyses.—See page 78.

No. 20. A polluted supply. It is probable that even the best protection in the way of construction would not preserve the purity of this supply. One should be secured in a better location.

Location of farm.—Oakland, Minn.

Date of visit.—August 1, 1908.

Size.—Two hundred and thirty-five acres.

Kind of farming.—General.

Topography.—Elevation of ground between house and outbuildings about 1½ feet, with a very gradual slope toward house and stables.

Source of water supply.—(See fig. 20.) Well partly under doorstep of house; 30 feet in depth; casing, cemented stone. *Strata:* Surface soil, 3 feet; remainder clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The house cellar, about 4 feet distant, contained 2 feet of water. Well water has peculiar taste whenever cellar fills, showing that there is chance of pollution from upper strata. This well is undoubtedly dangerous during wet seasons.

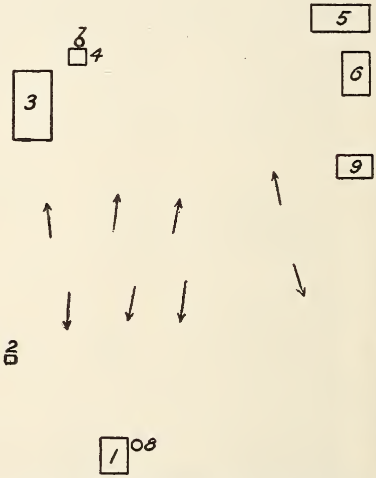

Fig. 20.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 20: 1, House; 2, privy; 3, barn and stables; 4, tool shed; 5, storehouse and corncrib; 6, granary; 7, cattle well; 8, well; 9, old log house.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good with exception of cellar, which contained water which as fast as pumped out flows in from surrounding saturated earth; stables very good; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 21. A good supply. This supply could be improved by installing a tight casing.

Location of farm.—Rochester, Minn.

Date of visit.—August 4, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—General.

Topography.—The ground slopes from the house in the direction of the stables, which are about 7 feet lower.

Source of water supply.—(See fig. 21.) Well about 25 feet from house, 50 feet from stables; 30 feet in depth; casing, uncemented stone. *Strata:* Surface soil, 3 feet; clay, 10 feet; gravel, 17 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. Mouth of well protected with tight board cover. Privy about 50 feet from well on same level, but vault is well protected.

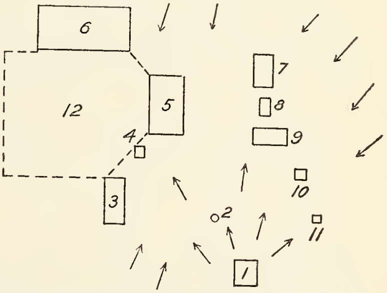

FIG. 21.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 21: 1, House; 2, well; 3, hogpen; 4, stable well and pump house; 5, stable; 6, barn and stables; 7, granary; 8, corncrib; 9, tool shed; 10, smokehouse; 11, privy; 12, barnyard.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House and stables excellent; privy good, tightly boxed vault, well protected.

Milk.—Sold to dealer; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 22. A polluted supply. A safe supply could be secured by proper drainage and by improving the casing and covering.

Location of farm.—South Haven, Minn.

Date of visit.—August 14, 1908.

Size.—One hundred and fifty acres.

Kind of farming.—General.

Topography.—The stables and house are on the same level; the well is about 2 feet below. The surface flow from outbuildings and barnyard is partly in the direction of the well.

Source of water supply.—(See fig. 22.) Well about 20 feet from house; 14 feet in depth; casing, $1\frac{1}{2}$-inch wooden planks. *Strata:* Clay, 13 feet, and gravel and sand, 1 foot. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Surface drainage from house and outbuildings enters in case of heavy rains. Mouth of well is poorly covered with rough boards.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A stagnant pond lies about 50 feet away, but at a much lower level; another stagnant pond is located about 200 feet in opposite direction from well.

Sanitary conditions of farmhouse and outbuildings.—House and stables poor; privy very poor, open vault, unprotected and shows entire lack of care.

Milk.—Entire supply made into butter; sanitary care very poor.

Water-borne diseases.—One case of typhoid fever, a young woman 20 years old, occurred on the place during the early spring of 1908. She had made several visits to neighbors, but no record of any cases could be found among the people she visited. It is impossible with the data at hand to locate the source of infection.

Analyses.—See page 78.

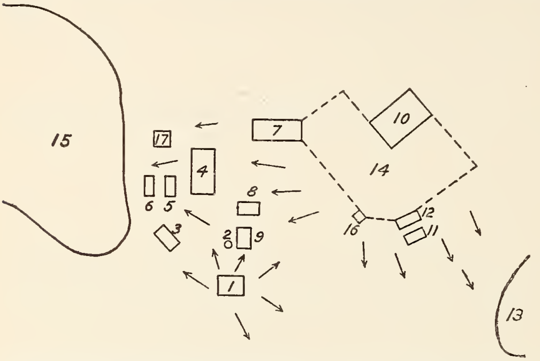

FIG. 22.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 22: 1, House; 2, well; 3, tool shed; 4, granary; 5, corncrib; 6, corncrib; 7, wagon shed; 8, smokehouse; 9, tool shed; 10, stables; 11, chicken house; 12, corncrib; 13, pond; 14, barnyard; 15, pond; 16, privy; 17, hogpen.

No. 23. A polluted supply. This supply if protected could be improved, but probably could not be made safe.

Location of farm.—St. Cloud, Minn.

Date of visit.—August 14, 1908.

Size.—Two hundred and forty-eight acres.

Kind of farming.—General.

Topography.—The ground surrounding the farmhouse and outbuildings is very level.

Source of water supply.—(See fig. 23.) Well about 26 feet from house; 44 feet in depth; casing, brick. *Strata:* Clay, hardpan, gravel, and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect*: Bad. The mouth of the well is poorly covered with rough boards and receives surface wash.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care very poor.

Water-borne diseases.—One case of typhoid on this place some eighteen years previous to visit.

Analyses.—See page 78.

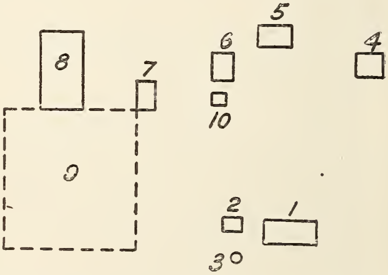

FIG. 23.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 23: 1, House; 2, smokehouse; 3, well; 4, granary; 5, chicken house; 6, corncrib; 7, corncrib; 8, barn and stables; 9, barnyard; 10, privy.

No. 24. A polluted supply. This supply could be made very satisfactory by installing a good casing and tight covering.

Location of farm.—Sauk Center, Minn.

Date of visit.—August 17, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Ground surrounding house and outbuildings is quite level. Well is located on same level as stables, but 1 foot below level of house.

Source of water supply.—(See fig. 24.) Well about 70 feet from house; 25 feet in depth; 3 feet square; casing, wood. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. Surface wash and back flow from pump enter freely. Large fungous growths project from the sides of well at surface of water. Well is used for cooling milk and other articles of food.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables poor; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care very poor.

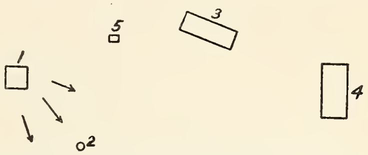

FIG. 24.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 24: 1, House; 2, well; 3, tool shed; 4, stable; 5, privy.

Water-borne diseases.—One case of typhoid, a farm hand, appeared on this place August 7, 1908. The patient had not used water from any other source for over a month. This being the busy harvest season, the man had been confined closely to work for over a month and recalled no trips away from home except a visit now and then to near neighbors. At that time no other cases were present in the immediate vicinity. One case of typhoid was located some 3 miles from this farm, but no communication whatever could be traced from this source to the patient or to any of the near neighbors. The patient lays the source of his infection to the well, but although the sanitary surroundings of the well are bad, it would be impossible to fix this as the infecting agent without more definite information.

Analyses.—See page 78.

No. 25. A polluted supply. This supply could be made safe by installing a good casing and adding the necessary surface protections.

Location of farm.—Crookston, Minn.

Date of visit.—September 10, 1908.

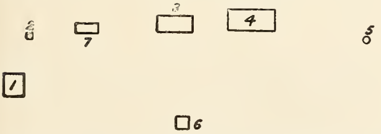

FIG. 25.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 25: 1, House; 2, privy; 3, granary; 4, stables; 5, well; 6, tool shed; 7, chicken coop.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Level prairie; no natural slopes drain the surface in any direction.

Source of water supply.—(See fig. 25.) Well about 50 feet from stable; 40 feet in depth; 3 feet square; casing, boards. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. The covering admits both surface wash from barnyard and back flow from pump; casing broken in many places. Pieces of wood, fungous growths, and other decomposing organic materials were floating on surface of water.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None permanent.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy poor, open vault with very little protection.

Milk.—Made into butter and sold in Crookston; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 26. A polluted supply. As there are many other much more favorable locations within a few rods, it would be better to relocate than to attempt to improve the structure materially.

Location of farm.—Huot, Minn.
Date of visit.—September 11, 1908.
Size.—Two acres.
Kind of farming.—General.
Topography.—House and outbuildings located on level land with a very gradual slope in the direction of the river and also away from the river. House about 25 feet above Red Lake River. The slope right at river bank is very abrupt.
Source of water supply.—(See fig. 26.) Well about 20 feet from river and 10 feet above river bed; 12 feet in depth; casing, boards. *Strata:* Sand, gravel, and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. Surface wash from steep bank above flows directly into well. On date of visit well contained all sorts of organic material, both living and dead. The pump being out of order, a pail and rope were used. The first pail drawn contained two frogs, numerous bugs, sticks, grass, and considerable mud. The people on the farm continue to drink the water.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—Red Lake River flows by edge of farm. The river water is used for drinking purposes during the winter season.
Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy poor, open vault and unprotected.

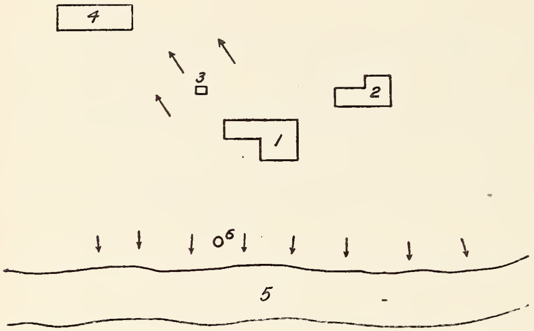

Fig. 26.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 26: 1, House and general store; 2, stables; 3, privy; 4, beehouse; 5, Red Lake River; 6, well.

Milk.—Buy milk from creamery.
Water-borne diseases.—One case of typhoid occurred on this farm during the spring of 1908. A man, aged 38, was taken ill April 1. The patient had been at home for some time previous to the infection and had taken care of his brother, who contracted the disease February 28. He drank water from the river entirely from November 15 to date of illness. This case may be one of infection from the river water or by contact in caring for his brother during his illness.
Analyses.—See page 78.

No. 27. A polluted supply. This supply could be very much improved by installing a good casing, by banking the surface to carry away surface water, and by the installation of a pump.

Location of farm.—Thief River Falls, Minn.
Date of visit.—September 14, 1908.
Size.—One hundred and forty-five acres.
Kind of farming.—Grain.
Topography.—Surface on which farm buildings are located is level prairie land.

Source of water supply.—(See fig. 27.) Well about 20 feet from house; 13 feet in depth; 3 feet square; casing, boards. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Rope and tin bucket. *Sanitary aspect:* Bad. Well receives surface wash from all directions; mouth surrounded with decomposing straw. The well is used to cool food products, and just before date of visit a can of milk had been spilled into it; odor and appearance of water very bad. The utensils used in drawing water were very dirty.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected. This is really a primitive farm and has been occupied only three years.

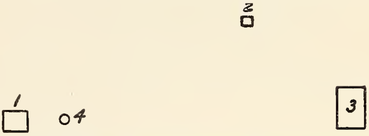

Fig. 27.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 27: 1, House; 2, privy; 3, stable; 4, well.

Milk.—Made into butter and sold in Thief River Falls; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 28. A polluted supply. This supply could be improved by completing the casing and making a tight cover.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

Size.—Three hundred and twenty acres.

Kind of farming.—General.

Topography.—Buildings are on level prairie. Drainage from farm buildings by artificial means reaches the Middle Branch River.

Source of water supply.—(See fig. 28.) Well about 40 feet northeast of house; 18 feet in depth; casing, 10 feet brick and 8 feet boards. *Strata:* Surface loam, 2 feet; yellow clay, 5 feet; gravel, sand, and clay, 6 feet; hardpan, 5 feet. *Yield:* Insufficient during months of March and April. *Use:* Drinking and general farm purposes. *Method of lifting:* Rope and bucket. *Sanitary aspect:* Bad. Mouth of well covered with loose boards; surface wash enters freely.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Middle Branch River flows near house.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; privy poor, open vault and unprotected.

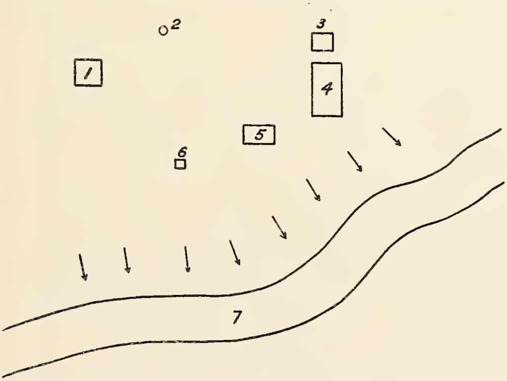

Fig. 28.—Sketch showing the topography and the location of buildings in the vicinity of dug well No. 28: 1, House; 2, well; 3, granary; 4, stables; 5, tool shed; 6, privy; 7, Middle Branch River.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

BORED WELLS.

No. 1. A polluted supply. This supply could be made safe by installing a tight casing and good covering.

Location of farm.—Chikio, Minn.
Date of visit.—August 10, 1908.
Size.—One hundred and sixty acres.
Kind of farming.—General.
Topography.—The ground on which the house and outbuildings are located is level.

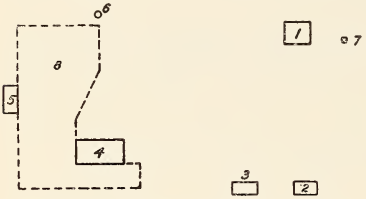

FIG. 29.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 1: 1, House; 2, granary; 3, tool shed; 4, barn and stables; 5, hogpen; 6, well; 7, privy; 8, barnyard.

Source of water supply.—(See fig. 29.) Well about 50 feet from stables and at corner of barnyard; 55 feet in depth; casing, board, 1½ feet in diameter. *Strata:* Clay, 40 feet; sand and gravel, 15 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; too near barnyard. Mouth of well is raised 2½ feet above surrounding surface; board covering in poor repair.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House fair; stables good; privy very poor, open vault and unprotected.
Milk.—Sold to butter factory; sanitary care fair.
Water-borne diseases.—One case of typhoid, July 15, 1908. The patient, a hired man, had not visited Morris or any of the surrounding villages for some time previous to infection, which could not be traced. No other people on the farm became infected.
Analyses.—See page 78.

No. 2. A polluted supply. The installation of a good casing and the proper draining or the removal of the barnyard would make this a satisfactory supply.

Location of farm.—Sauk Center, Minn.
Date of visit.—August 17, 1908.
Size.—One hundred and twenty acres.
Kind of farming.—General.
Topography.—Surface adjacent to farm buildings quite level. The house, however, is elevated about 1 foot above the level of the well; drainage from the house would be in the direction of the well and stables.

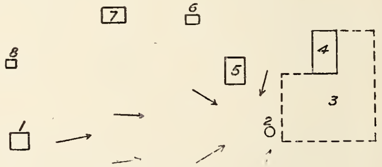

FIG. 30.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 2: 1, House; 2, well; 3, barnyard; 4, barn and stables; 5, granary; 6, tool shed; 7, chicken house; 8, privy.

Source of water supply.—(See fig. 30.) Well several feet from barnyard; 27 feet in depth; no casing. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Wooden pump. *Sanitary aspect:* Bad. Location near barnyard and on same level makes contamination from that source possible. Surface wash and back flow from pump enters well freely. Occasionally water has a bad taste, which is probably due to wash from barnyard.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy very poor, open vault and entirely unprotected.

Milk.—Cream sold to creamery; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 3. A badly polluted supply. This supply could be rendered fit for use by installing a pump and protecting the well from surface pollution.

Location of farm.—Argyle, Minn.

Date of visit.—September 12, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Surface surrounding buildings about 12 feet above the bed of Snake River; very level with the exception of an abrupt fall 50 feet from the house toward the river.

Source of water supply.—(See fig. 31.) Well about 30 feet from house; 10 feet in depth; casing, 6-inch tin pipe. *Stratum:* Blue prairie clay. *Yield:* Abundant except during dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Tin bucket with a loose bottom. *Sanitary aspect:* Very bad. One bucket of water contained frogs, bugs, sticks, straw, and mud. The covering of the well consists of the top of a milk can, which evidently is used only when the water becomes unusually filthy.

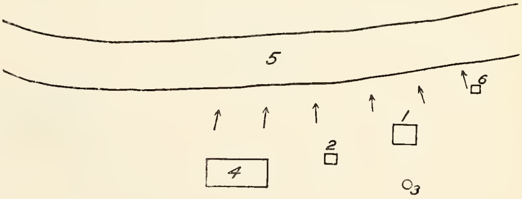

FIG. 31.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 3: 1, House; 2, tool shed; 3, well; 4, stables; 5, Snake River; 6, privy.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One river.

Sanitary condition of farmhouse and outbuildings.—House very poor, a disgusting odor making it almost impossible to remain inside; stable very poor; privy very poor, open vault and entirely unprotected.

Milk.—The entire supply is used by the family; sanitary care very poor, all utensils filthy.

Water-borne diseases.—Six cases of typhoid fever occurred in this family during the spring months of 1908: A girl, age 18 years, taken ill March 25; a boy, 12 years, April 15; a boy, 8 years, May 26; a girl, 15 years, May 30; a woman, 41 years, May 31; a boy, 18 years, June 1. The original case of this infection was brought from Oslo, Minn., where the girl had been employed in a hotel as a servant. The other cases were probably infected by contact, although the well, also, might have been a means of carrying the infection.

Analyses.—See page 78.

No. 4. A badly polluted supply. The sanitary condition of this supply could be improved by proper surface protection, and by installing a good pump the water could be made safe as long as the tin casing remained in good condition.

Location of farm.—Argyle, Minn.

Date of visit.—September 12, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Surface surrounding farm buildings is level prairie.

Source of water supply.—(See fig. 32.) Well about 50 feet south of house; 13 feet in depth; casing, 6-inch tin pipe. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general house purposes. *Method of lifting:* Rope and tin bucket. *Sanitary aspect:* Poor. This well is so situated that it receives surface wash whenever precipitation is sufficient to cover the surface. No covering is used for protection, so the water necessarily receives considerable surface dust and organic pollution.

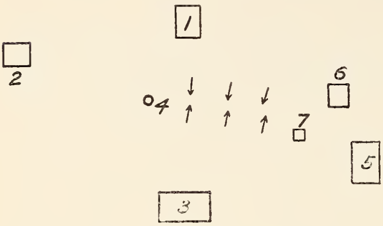

Fig. 32.—Sketch showing the topography and the location of buildings in the vicinity of bored well No. 4. 1, House; 2, granary; 3, stables; 4, well; 5, chicken house; 6, tool shed; 7, privy.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables good; privy has open vault and is unprotected.

Milk.—Used on farm; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 5. Probably a good supply. The supply should be farther from the outbuildings.[a]

Location of farm.—Minneapolis, Minn.

Date of visit.—December, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—Land slopes gently toward a marsh which borders Maxwell Bay; house and outbuildings near edge of marsh.

Source of water supply.—(See fig. 33.) Well near house and barn; 21 feet in depth; casing, 6-inch tile. *Strata:* Few inches black earth; 20 feet hard bluish clay; water-bearing stratum, quicksand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; barn poor.

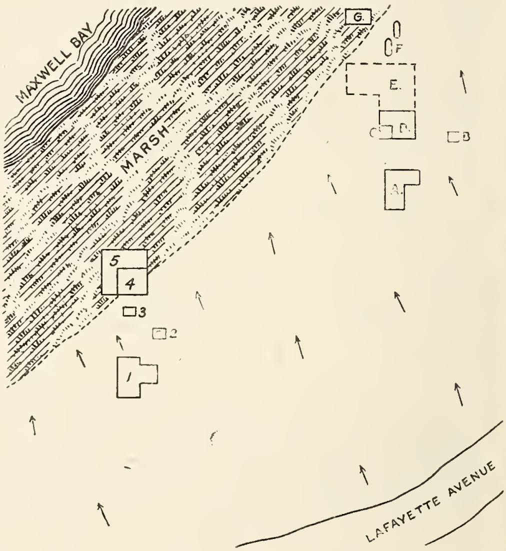

Fig. 33.—Sketch showing the topography and the location of buildings in the vicinity of bored wells Nos. 5 and 6: A, House of farm No. 5; B, well; C, privy; D, barn and wood shed; E, chicken yard; F, haystacks; G, ice house. 1, House of farm No. 6; 2, well; 3, privy; 4, horse and cow stables; 5, chicken yard.

Milk.—Occasionally supplied summer residents in the neighborhood; sanitary care poor.

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[a] Data for this report furnished by Dr. H. W. Hill, of the Minnesota State Board of Health.

Water-borne diseases.—Two cases of typhoid fever, the first, a man 32 years old, taken sick September 11, 1908, and the second, a girl 10 years old, taken sick October 20. Source of infection for first case, Minneapolis; for second, contact or infected milk.

Analyses.—See page 78.

No. 6. Probably a good supply. The supply should be farther from the outbuildings.[a]

Location of farm.—Minneapolis, Minn.

Date of visit.—December, 1908.

Size.—Two acres.

Kind of farming.—General.

Topography.—Land slopes gently toward a marsh which borders Maxwell Bay; house and outbuildings near edge of marsh.

Source of water supply.—(See fig. 33.) Well near house, privy, and stables; 21 feet in depth; casing, 6-inch tile. *Strata:* Few inches black earth, 20 feet hard bluish clay; water-bearing stratum, quicksand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stable poor.

Milk.—Obtained from neighbor three-fourths mile away, except about 5 quarts, taken at different times, from next door (see No. 5, fig. 33).

Water-borne diseases.—Two cases of typhoid fever; first, a girl 15 years old, taken sick October 13, 1908; second, a boy 10 years old, taken sick October 18. Source of infection, milk or contact.

Analyses.—See page 78.

DRILLED WELLS.

No. 1. A polluted supply. The pollution may be due to surface water following the iron pipe to the point where it touches the rock and possibly gaining entrance there, but is more probably due to leaks in the cistern holding well water a short distance away. Both well and cistern should be protected from surface wash and seepage from the upper strata.

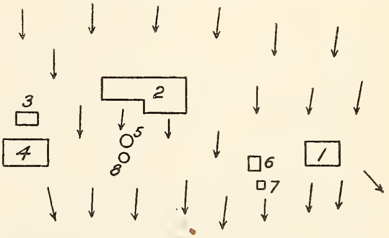

FIG. 34.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 1: 1, House; 2, stables; 3, corncrib; 4, hay shed; 5, well; 6, chicken house; 7, privy; 8, cistern (well).

Location of farm.—Red Wing, Minn.

Date of visit.—July 24, 1908.

Size.—Eighteen acres.

Kind of farming.—Dairy.

Topography.—All the buildings are on a steep incline.

Source of water supply.—(See fig. 34.) Well in barnyard; 138 feet in depth; casing, 6-inch iron pipe to a depth of 17 feet, remainder rock. *Strata:* Clay, 17 feet; remainder limestone rock. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, horse sweep used for power. *Sanitary aspect:* Fair. Well in center of barnyard below level of stable. Casing attached to pump.

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[a] Data for this report furnished by Dr. H. W. Hill, of the Minnesota State Board of Health.

Cisterns.—Two. A cement cistern used to hold surplus supply for cattle is located in barnyard near pump. This cistern is evidently very badly polluted, as the water is discolored and has a very unpleasant odor. The house cistern is used for washing purposes and for cooling milk.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables poor; privy poor, unprotected vault.

Milk.—Retailed in Red Wing; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 2. A badly polluted supply. The practice of using an unprotected dug well as a surface reservoir is undesirable, to say the least. It is an open question whether this supply is responsible for the three typhoid fever cases on the farm.

Location of farm.—St. Peter, Minn.

Date of visit.—July 27, 1908.

Size.—One hundred and twenty acres.

Kind of farming.—General.

Topography.—The ground immediately surrounding the house has been artificially raised about 6 inches to turn surface wash.

Source of water supply.—(See fig. 35.) Well about 35 feet from house; 167 feet in depth, dug 25 feet and drilled 142 feet; casing, 2-inch iron pipe; well pit, 25 feet deep, cased with uncemented stone. *Strata:* Surface soil and clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Very bad. The well pit is used as a supply tank, the water being pumped out of the deep well by a windmill into the well pit. The mouth of the pit is very poorly protected with loose boards, which are lower than surrounding surface. During heavy rains water runs freely into well pit, and the privy, which is 75 feet away, undoubtedly contributes to the surface wash which finally reaches the well pit.

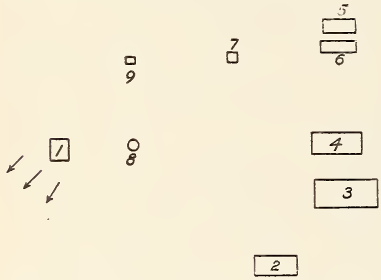

FIG. 35.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 2: 1, House; 2, granary; 3, stables; 4, chicken house; 5, corncrib; 6, corncrib; 7, smokehouse; 8, well; 9, privy.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Shallow puddles during wet season, no permanent ponds.

Sanitary condition of farmhouse and outbuildings.—House good; barn fair; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases.—Three positive cases of typhoid fever, a man and a woman taken sick July 7, 1908, and a woman taken sick July 17. The history of these cases shows visits to St. Peter; only one of these patients drank city water, however, and she was taken sick three days later, which allows too short a period for the incubation of the disease. No other cases of typhoid have been reported recently among the users of city water. No other cases have been reported in the rural districts in that vicinity, nor have any of the patients visited homes or associated with people known to have typhoid. All the patients were users of the farm water supply.

Analyses.—See page 78.

No. 3. A polluted supply. Extra precautions should be taken in the case of this well to cover the casing properly and avoid the inflow of back wash from the pump, which at times may cause a serious pollution.

Location of farm.—Owatonna, Minn.
Date of visit.—July 30, 1908.
Size.—One hundred and sixty acres.
Kind of farming.—General.
Topography.—Gradual slope from the house toward the stables; difference in elevation between house and stables about 2½ feet.
Source of water supply.—(See fig. 36.) Two wells (No. 3 and No. 10). Well No. 3, near stables, 107 feet in depth; casing, 6-inch iron pipe. *Strata:* Blue clay and small quantity of rock. *Yield:* Abundant. *Use:* For cattle only. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. This well is quite near stables and barnyard, but its depth and especially good surface protection will undoubtedly keep it free from pollution. Well No. 10, about 50 feet from house, 100 feet in depth, dug 40 feet and drilled 60 feet; casing, stone in dug portion, 6-inch iron pipe in drilled portion. *Strata:* Blue clay and 10 feet of rock at bottom. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Except in cases of heavy rains there is little opportunity for surface wash.
Cisterns.—One, used for drinking water.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault and unprotected.
Milk.—Sold to creamery; sanitary care fair.
Water-borne diseases.—One case of typhoid, taken sick April 11, 1908. The patient claims to have drunk no water except from well No. 10. In one other case of typhoid, about a mile and a half from this farm, the patient had just recovered. Neither patient admits having visited the other at any time previous to infection.

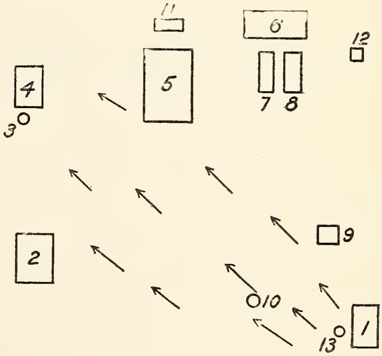

FIG. 36.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 3: 1, House; 2, stables; 3, well; 4, stables; 5, granary; 6, henhouse; 7, corncrib; 8, corncrib; 9, smokehouse; 10, well; 11, hogpen; 12, privy; 13, cistern.

Analyses.—See page 78.

No. 4. A polluted supply. This supply offers good opportunity for occasional serious pollution due to improper construction. The sanitary condition of the water could undoubtedly be improved by extending the casing to the base of the pump, by properly protecting the well pit, or by covering the mouth of the casing with a tight cover.

Location of farm.—Owatonna, Minn.
Date of visit.—July 30, 1908.
Size.—Two hundred and forty acres.
Kind of farming.—General.
Topography.—Difference in elevation between house and granary about 8 feet; well located on level with house and stables.

Source of water supply.—(See fig. 37.) Well near corner of barn; 90 feet in depth; casing, 6-inch iron pipe; well pit 10 feet deep, cased with boards. *Strata:* Clay, 40 feet; remainder gravel and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Bad. Very near stables and surface wash sometimes fills the well pit. The iron casing does not extend to the pump, so when the pit is full this surface water may enter the well directly.

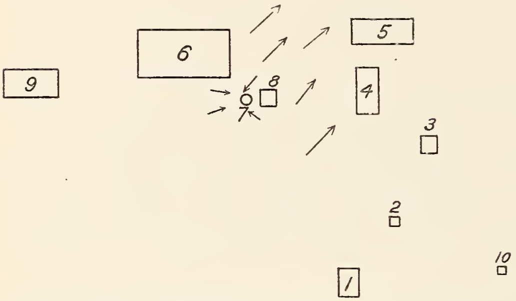

FIG. 37.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 4: 1, House; 2, wood shed; 3, smokehouse; 4, chicken house; 5, granary; 6, barn and stables; 7, well; 8, milk house; 9, hogpen; 10, privy.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables good; privy poor, open vault and unprotected.

Milk.—Sold to creamery; sanitary care fair.

Water-borne diseases. — One case of typhoid, a man, taken sick October 12, 1908. No other cases were known to be in the neighborhood at that time. Patient previously had visited a great many farms with a thrashing crew.

Analyses.—See page 78.

No. 5. A polluted supply. This pollution is due chiefly to inflow of water from the dug portion directly into the deep well casing. The water could be greatly improved by extending the casing, then filling part of the dug portion—say, to within 10 feet of the surface and using this as a well pit—and carefully installing means of excluding surface pollution.

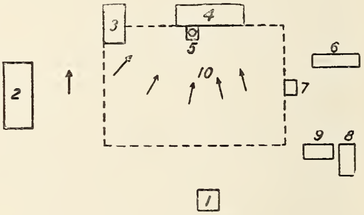

FIG. 38.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 5: 1, House; 2, barn and stables; 3, stables; 4, stables; 5, well and milk house; 6, chicken house; 7, granary; 8, wood and wagon shed; 9, tool shed; 10, barnyard.

Location of farm.—Rochester, Minn.

Date of visit.—August 4, 1908.

Size.—One hundred and eighty-five acres.

Kind of farming.—General.

Topography.—Difference in elevation between house and stables about 3 feet; slope from house toward stables; stables on same level as well.

Source of water supply.—(See fig. 38.) Well in barnyard near stables; 60 feet in depth, dug 30 feet and drilled 30 feet; casing, dug portion uncemented stone, drilled portion 3-inch iron casing. *Strata:* Sand and clay, 30 feet; remainder limestone. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Bad. Mouth of well covered with loose boards. Surface immediately around well has been raised, but not enough to prevent surface wash into dug portion during heavy rains. Water from dug portion is said to flow into the casing of drilled portion at times.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables very poor; milk house very poor; privy poor, unprotected vault.

Milk.—Cream sold to butter factory; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 6. A polluted supply. The protection of this well is apparently good, yet the water is evidently polluted. The bad location of the well and the poor protection of the mouth of the well may be responsible for this pollution. It is also possible that pollution is drawn from some underground source, as the well and the lake have about the same level.

Location of farm.—Alexandria, Minn.

Date of visit.—August 12, 1908.

Size.—One hundred and forty-one acres.

Kind of farming.—General.

Topography.—A small creek separates house from most of the outbuildings. The depression formed by creek is very narrow, but about 6 feet deep. Lake Andrews is located about 40 rods from house and at a level 15 or 20 feet lower.

Source of water supply.—(See fig. 39.) Well about 25 feet from house; 80 feet in depth; casing, 3-inch iron pipe attached to base of pump. *Strata:* Gravel, 10 feet; few feet red clay; 50 feet blue clay; and 10 feet of sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Mouth of well several feet below level of house and of surrounding ground; covering very poor.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Lake Andrews 40 rods away; flowing spring near stables; small creek leading from spring to lake.

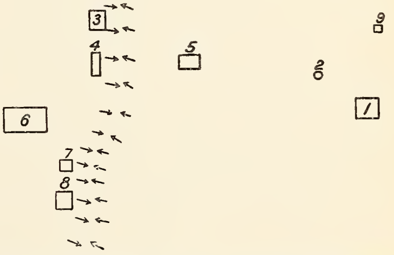

FIG. 39.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 6: 1, House; 2, well; 3, hogpen; 4, corncrib; 5, chicken coop; 6, barn and stables; 7, granary; 8, tool shed; 9, privy.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 7. A polluted supply. The location of the well is bad, yet with good surface protection the supply might be made safe.

Location of farm.—Alexandria, Minn.

Date of visit.—August 12, 1908.

Size.—Two hundred and twenty acres.

Kind of farming.—General.

Topography.—The house is elevated slightly above level of stables; other outbuildings on same level with house. The surface slopes very abruptly from stables on side away from house. Drainage from stables and barnyard empties into a pond about 8 rods distant.

Source of water supply.—(See fig. 40.) Well about 15 feet from house; 60 feet in depth; casing, iron pipe. *Strata:* Clay and sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad; too near privy. Covering in poor condition; waste water from pump sinks into ground around the casing.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Several ponds.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to creamery; sanitary care very poor.

Water-borne diseases.—About one year previous to date of visit an infection of typhoid occurred on this farm and gave rise to eight cases of typhoid. The attending physician lays the source to a shallow well then in use by the family, which has since been filled.

Analyses.—See page 78.

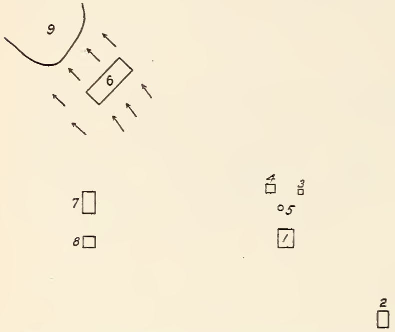

FIG. 40.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 7: 1, House; 2, ice house; 3, privy; 4, outdoor kitchen; 5, well; 6, barn and stable; 7, wagon shed; 8, granary; 9, pond.

No. 8. A good supply. If the well pit was tightly cased it would give greater protection against back wash from the pump and inflow from the upper strata.

Location of farm.—Sauk Center, Minn.

Date of visit.—August 17, 1908.

Size.—Three hundred and thirty acres.

Kind of farming.—General.

Topography.—The house is about 2 feet above granary and well and about 4 feet above barn.

Source of water supply.—(See fig. 41.) Well about 40 feet from house; 153 feet in depth; casing, 4-inch iron pipe; well pit about 3 feet square, 10 feet deep, cased with boards. *Strata:* Yellow clay, 30 feet; hardpan, 12 feet; sand, 15 feet; clay, 90 feet; and about 5 feet of sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good. Mouth of well protected by tight covering. A small quantity of back flow enters well pit as drainage from pump cylinder.

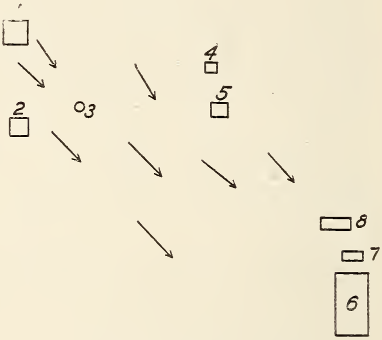

FIG. 41.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 8: 1, House; 2, granary; 3, well; 4, privy; 5, ice house; 6, barn and stables; 7, corncrib; 8, hogpen.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy poor, open vault and unprotected.

Milk.—Cream sold to creamery; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 9. A good supply.

Location of farm.—Crookston, Minn.
Date of visit.—September 10, 1908.
Size.—Two hundred and forty acres.
Kind of farming.—Grain.
Topography.—Level prairie.
Source of water supply.—(See fig. 42.) Well in combination ice and pump house; 200 feet in depth; casing, 2-inch iron pipe. *Strata:* Blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good. A double board covering protects the 10-foot well pit from surface wash and back flow, and casing extends to base of pump. More than the usual precautions are observed in protecting this well.
Cisterns.—One, used for washing.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy has open vault, slightly protected.
Milk.—Sold in Crookston; sanitary care fair.
Water-borne diseases.—None recorded.
Analyses.—See page 78.

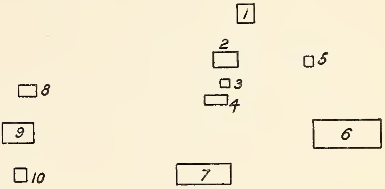

FIG. 42.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 9: 1, House; 2, woodshed; 3, privy; 4, chicken house; 5, well and ice house; 6, stables; 7, machine shed; 8, chicken coop; 9, machine shed; 10, hogpen.

No. 10. A polluted supply. The field observations show this to be a more offensively polluted water than is indicated by the analytical data. By carefully protecting the mouth of the well with a good covering and discontinuing the use of the well pit as a refrigerator the supply could be rendered safe.

Location of farm.—Crookston, Minn.
Date of visit.—September 10, 1908.
Size.—Three hundred and twenty acres.
Kind of farming.—Grain.
Topography.—Level prairie.
Source of water supply.—(See fig. 43.) Well about 50 feet from stables; 180 feet in depth; casing, 2-inch iron pipe. *Strata:* Unknown, probably blue clay. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The 2-inch iron casing is carried to within 14 feet of surface and there empties its overflow into a well pit, which is cased with an iron casing about 2½ feet in diameter. The well pit contained several feet of water, on which were floating decomposed cream and other contaminations of surface origin.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; privy poor, open vault and unprotected.
Milk.—Made into butter; sanitary care very poor.
Water-borne diseases.—Two cases of typhoid fever occurred during the summer of 1898. The same water supply was used at that time. The family having moved away, no definite data could be found regarding these cases.
Analyses.—See page 78.

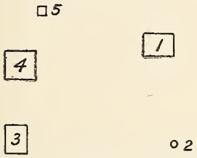

FIG. 43.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 10: 1, House; 2, well; 3, granary; 4, stables; 5, privy.

No. 11. A polluted supply. The city of Crookston is located several miles from this farm, and a well sunk there for a municipal supply drained the well under discussion. This would seem to indicate that this well is connected with an extensive underground supply which may be polluted at a more or less distant point. Without considerable investigation it would be impossible to determine whether or not this supply is perfectly safe.

Location of farm.—Crookston, Minn.

Date of visit.—September 10, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 44.) Well about 30 feet from corner of stables; 203 feet in depth; casing, 2½-inch iron pipe. *Strata:* Blue clay, 20 feet; red clay, 150 feet; mixed sand and clay, 27 feet; rock, 3 feet; and fine sand, 3 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair; near barnyard and stable, yet for a well as deep and as carefully protected as this one little danger could be expected from that source. Casing extends to base of pump. Water rises to within 17 feet of surface.

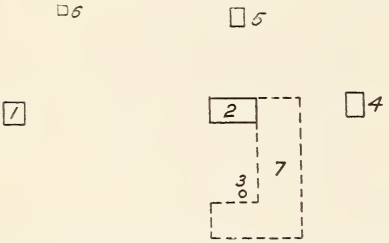

FIG. 44.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 11: 1, House; 2, stables; 3, well; 4, chicken house; 5, granary; 6, privy; 7, barnyard.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables very poor; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

No. 12. A polluted supply. Although the surface protection of this well is good, the environment is bad; the pollution is probably due to seepage from the upper strata down the outside of the casing. For domestic use a well should be sunk farther from the stables and barnyard.

Location of farm.—Hallock, Minn.

Date of visit.—September 17, 1908.

Size.—Four hundred and eighty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 45.) Well about 5 feet from stables; 75 feet in depth; casing, 2½-inch iron pipe. *Strata:* Hardpan and a clay mixture. *Yield:* Abundant, except in very dry seasons. *Use:* Drinking, when the supply of cistern water gives out, and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair; too near stables. Surface of well is thoroughly protected from surface wash and back flow.

Cisterns.—One, used for drinking, but was empty on date of visit.

Lakes, rivers, ponds, and springs.—A few ponds, dug for collecting surface water for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House poor; stables good; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

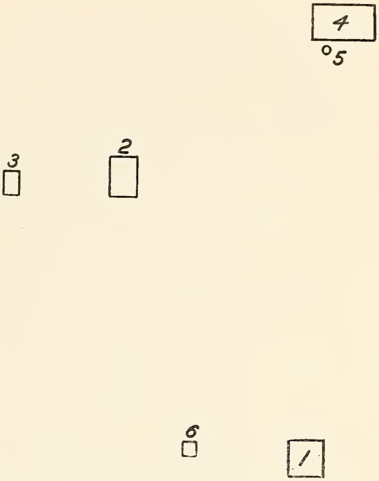

Fig. 45.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 12: 1, House; 2, feed house; 3, chicken house; 4, barn and stables; 5, well; 6, privy.

No. 13. A good supply. It is advisable to prevent collection of water in the well pit.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—Two hundred and thirty acres.

Kind of farming.—General.

Topography.—Level, sandy surface. Drainage is carried artificially in several directions.

Source of water supply.—(See fig. 46.) Well in pump house about 25 feet from house; 112 feet in depth; casing, 3-inch iron pipe; well pit 10 feet in depth, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, gasoline engine used for power. *Sanitary aspect:* Good. Well is protected from surface wash, yet a small quantity of back flow enters well pit; about 1 foot of water in well pit on date of visit. Casing extends to base of pump, so there is no opportunity for direct pollution.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house good; privy good, open vault quite well protected.

Milk.—Cream shipped to St. Paul; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 78.

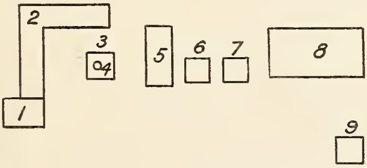

Fig. 46.—Sketch showing the topography and the location of buildings in the vicinity of drilled well No. 13: 1, House; 2, wagon shed; 3, pump house; 4, well; 5, chicken house; 6, granary; 7, granary; 8, barn and stables; 9, granary.

DRIVEN WELLS.

No. 1. A good supply, except for the temporary pollution of the storage tank.

Location of farm.—Excelsior, Minn.

Date of visit.—June 30, 1908.

Size.—One hundred and forty acres.

Kind of farming.—General.

Topography.—Surface is irregular, sloping gradually toward the creek. The low, flat land surrounding the elevation is subject to overflow during the spring season.

Source of water supply.—(See fig. 47.) Well about 30 feet from house; 150 feet in depth; casing, 3-inch iron pipe. *Strata:* Surface clay, 10 feet; hardpan, 100 feet; gravel, 40 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump with windmill and gasoline engine for power. *Storage tank:* Wood, capacity 3,800 gallons. *Sanitary aspect:* Good. The well pit is dry and well protected from surface wash. A short time before date of visit the storage tank began to leak and the owner emptied several pecks of meal into the tank. The meal soon decomposed and gave the water a bad taste and odor. The cesspool is a considerable distance from the well.

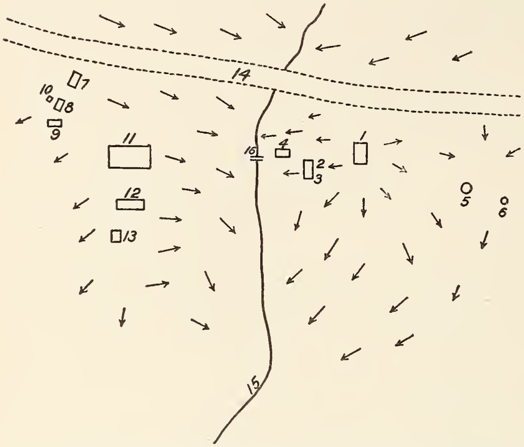

FIG. 47.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 1: 1, House; 2 and 3, pump house and elevated water tank; 4, ice house; 5, cesspool; 6, cesspool outlet; 7, farmhouse; 8, shed; 9, chicken coop; 10, privy; 11, barn; 12, shed; 13, corncrib; 14, road; 15, creek; 16, bridge.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—One lake, several springs, and one creek on farm.

Sanitary condition of farmhouse and outbuildings.—House very good; stables fair; privy good, connected with cesspool.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—For both well water and tank water, see page 79.

No. 2. A polluted supply. This could be made a safe supply by protecting the well pit from surface wash.

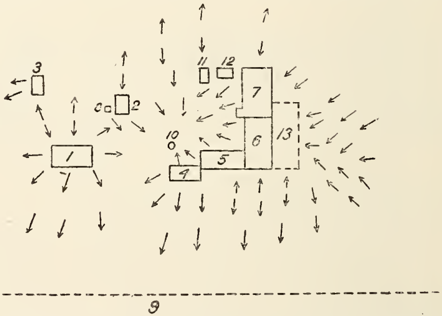

FIG. 48.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 2: 1, House; 2, ice house; 3, tool shed; 4, tool shed; 5, hay barn; 6, hay barn; 7, stables; 8, privy; 9, public road; 10, well; 11, corncrib; 12, corncrib; 13, barnyard.

Location of farm.—New Brighton, Minn.

Date of visit.—July 3, 1908.

Size.—Forty acres.

Kind of farming.—General.

Topography.—The land in general slopes away from the house and outbuildings and toward the well. The yard and basements of stables are approximately 6 feet lower than surface of well.

Source of water supply.—(See fig. 48.) Well surrounded by farm buildings; 160 feet in depth; casing, 2-inch iron pipe, well protected at surface. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and windmill. *Sanitary aspect:* Fair. Slope toward well very gradual; in wet weather well pit fills with water.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House fair; stables very poor; privy poor, unprotected vault.

Milk.—Used on farm; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

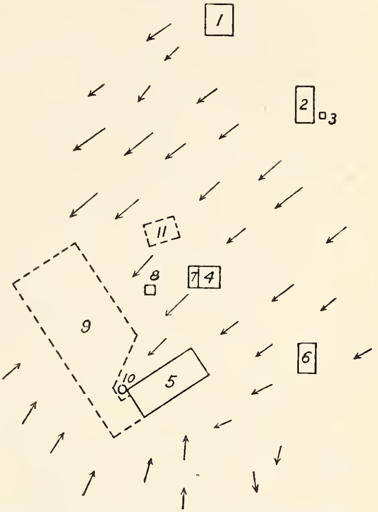

FIG. 49.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 3: 1, House; 2, storehouse and tool shed; 3, privy; 4, ice house; 5, stable; 6, chicken coop; 7, milk room; 8, hogpen; 9, barnyard; 10, well; 11, hay yard.

No. 3. A polluted supply. This well is in as bad a location as could be found on the farm and should be abandoned.

Location of farm.—St. Louis Park, Minn.

Date of visit.—July 6, 1908.

Size.—Sixty acres.

Kind of farming.—Dairy.

Topography.—The land surrounding buildings slopes abruptly from house and outbuildings in direction of stable and well. Well is about 3 feet lower than stable and 25 feet lower than house.

Source of water supply.—(See fig. 49.) Well is 10 feet from corner of stable; 60 feet in depth; casing, 2-inch iron pipe. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and windmill. *Sanitary aspect:* Very bad. Well is surrounded by manure heaps. The well pit, which is 10 feet deep, contained about 6 feet of manure leachings and surface wash; it sometimes completely fills. It seems that a worse location could scarcely be chosen for a well to be used for drinking purposes.

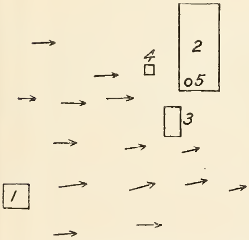

FIG. 50.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 4: 1, House; 2, barn and stable; 3, milk house; 4, privy; 5, well.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—A few ponds scattered about the farm.

Sanitary condition of farmhouse and outbuildings.—House very poor; milk house very bad; privy poor, unprotected vault.

Milk.—Retailed in city; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 4. A polluted supply. Both well and stables should be removed to higher ground.

Location of farm.—Minneapolis Minn.

Date of visit.—July 8, 1908.

Size.—One hundred and eighty acres.

Kind of farming.—Dairy.

Topography.—The surface falls abruptly from house to stable, a difference in elevation of about 20 feet.

Source of water supply.—(See fig. 50.) Well in corner of cow stables; 20 feet in depth, driven 10 feet and dug 10 feet; casing, wood and iron. *Strata:* Surface soil, 3 feet;

and sand, 17 feet; a ledge of rock forms bottom of well. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump and gasoline engine. *Sanitary aspect:* Very bad. The well pit usually contains from 1 to 2 feet of washings from under stable floor and back flow from pump.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; privy poor, unprotected vault.

Milk.—Retailed in Minneapolis; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 5. A polluted supply. By good surface protection the condition of the water could be much improved, though for domestic use a well should be sunk in a more sanitary location.

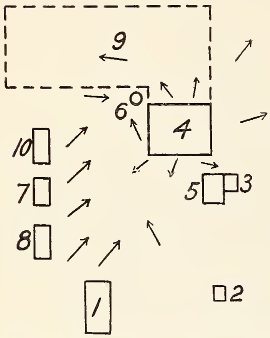

Fig. 51.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 5: 1, House; 2, privy; 3, corncrib; 4, barn and stables; 5, milk house and storehouse; 6, well; 7, stone house; 8, ice house; 9, barnyard; 10, wagon shed.

Location of farm.—Richfield, Minn.

Date of visit.—July 10, 1908.

Size.—Ninety acres.

Kind of farming.—Dairy.

Topography.—Drainage from most of the outbuildings finally reaches the barnyard at several points near the well.

Source of water supply.—(See fig. 51.) Well about 10 feet from corner of stables and same distance from barnyard; 50 feet in depth; casing, $1\frac{1}{2}$-inch iron pipe. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump; windmill for power. *Sanitary aspect:* Bad. Seepage and surface water from all directions flows directly into the well pit, sometimes standing several feet deep. The water pumped from the well had a decided odor.

Cisterns.—One, under house, but not used.

Lakes, rivers, ponds, and springs.—Lake Grass, a small shallow lake used only to water cattle.

Sanitary condition of farmhouse and outbuildings.—House fair; milk house poor; stables poor; privy poor, unprotected vault.

Milk.—Retailed in Minneapolis; sanitary care poor.

Water-borne diseases.—Last year three typhoid patients were cared for on this farm but all lived in Minneapolis when taken with the disease. The data at hand indicate that the typhoid was contracted in the city. It seems strange that the disease did not spread to those living on the farm.

Analyses.—See page 79.

No. 6. A good supply. There are other places in this yard that would be more suitable for the water supply.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 10, 1908.

Size.—Two hundred and thirty acres.

Kind of farming.—General.

Topography.—The house is about 5 feet above the outbuildings. The drainage from most of the outbuildings is in the direction of the pond in the barnyard.

Source of water supply.—(See fig. 52.) Well within a few feet of barnyard and about 15 feet from barn; 40 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sandy soil. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Hand pump; windmill for power. *Sanitary aspect:* Fair. The barnyard and other outbuildings form a rather dangerous environment. The surface of the well is quite well protected and the well pit was perfectly dry on date of visit.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—Lake Wood, used at times to water cattle.

Sanitary condition of farmhouse and outbuildings.—Good.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

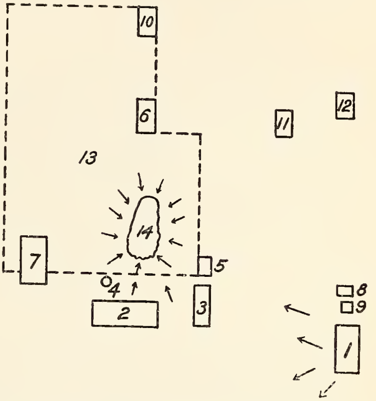

FIG. 52.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 6; 1, House; 2, horse barn; 3, corncrib; 4, well; 5, ice house; 6, granary; 7, cow stables; 8, wood shed; 9, privy; 10, sheep shed; 11, stone house; 12, storehouse; 13, barnyard; 14, pond.

No. 7. A polluted supply. Good protection against surface wash and seepage from the upper strata would greatly improve this supply. It is too near the stable, however.

Location of farm.—St. Paul, Minn.

Date of visit.—July 15, 1908.

Size.—Three acres.

Kind of farming.—Dairy.

Topography.—Low, level ground.

Source of water supply.—(See fig. 53.) Well in combined pump and milk house; 30 feet in depth; casing, 1½-inch iron pipe. *Strata:* Unknown; probably sandy loam. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill for power. *Sanitary aspect:* Bad. A well pit 3 feet square cased with ordinary wood casing extends to a depth of about 8 feet and contains several feet of surface wash and back flow from the pump. The mouth of the well pit is at a lower level than the stables and the house.

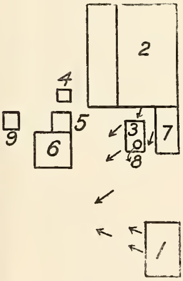

FIG. 53.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 7: 1, House; 2, hay barn and stables; 3, milk house; 4, privy; 5, stone house; 6, wood shed; 7, wagon shed; 8, well; 9, tool shed.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables fair; milk house fair; privy poor, unprotected vault.

Milk.—Retailed in St. Paul; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 8. A polluted supply. This supply could be made safe by installing a tight casing for the well pit and fitting a good cover around the base of the pump.

Location of farm.—St. Paul, Minn.

Date of visit.—July 15, 1908.

Size.—Ten acres.

Kind of farming.—Dairy.

Topography.—The surface slopes very abruptly from the points marked *x* (see fig. 54) in the direction of the outbuildings which are located on the level marked *y*. The difference in elevation between *x* and *y* is about 25 feet; a fall of probably 6 feet was noted between points *y* and *z*. The house and privy are located at a point intermediate between *x* and *y*, probably 15 feet above the other outbuildings.

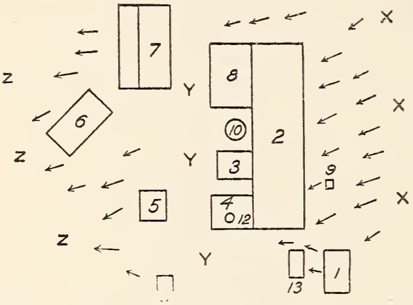

Fig. 54.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 8: 1, House; 2, cow stables; 3, horse stables; 4, well and tank house; 5, stone house; 6, storehouse; 7, cow stables; 8, hay shed; 9, privy; 10, silo; 11, old windmill base; 12, well; 13, stone house.

Source of water supply.—(See fig. 54.) Well in combined pump and milk house; 119 feet in depth; casing, 2½-inch iron pipe. *Strata:* Sand, 25 feet; the remainder clay and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Well pit 7 feet deep, cased with wood. The mouth of well pit is quite well protected from surface wash. The well is too near the stables and privy, and during wet seasons it would seem almost impossible to prevent seepage into the well pit from these sources.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables fair; milk house very poor; privy poor, open vault and unprotected.

Milk.—Retailed in St. Paul; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 9. A good supply.

Location of farm.—St. Paul, Minn.

Date of visit.—July 17, 1908.

Size.—Eighty acres.

Kind of farming.—Dairy.

Topography.—The house is about 3 feet above the well and about 12 feet above the stables. The general slope is away from the house in the direction of the well and outbuildings.

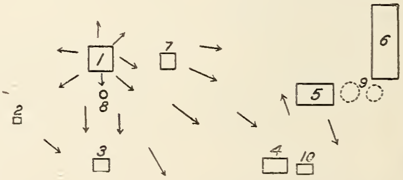

Fig. 55.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 9: 1, House; 2, privy; 3, outdoor kitchen; 4, tool and wagon shed; 5, horse barn; 6, cow stables; 7, milk house; 8, well; 9, silos; 10, tool shed.

Source of water supply.—(See fig. 55.) Well about 20 feet from house; 57 feet in depth, 22 feet dug and 35 feet driven, dug part filled to about 10 feet of surface; casing, 1½-inch iron pipe. *Strata:* Clay, 50 feet, and sand, 7 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables in bad location and receive little attention; milk house well cared for; privy poor, unprotected vault.

Milk.—Retailed in St. Paul; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 10. A good supply.

Location of farm.—Red Wing, Minn.

Date of visit.—July 23, 1908.

Size.—Seventy acres.

Kind of farming.—Dairy and general.

Topography.—The house is located on a level strip of ground sloping in three directions and is about 10 feet above the outbuildings.

Source of water supply.—(See fig. 56.) Well in milk room at back of house; 20 feet in depth; casing, 1¼-inch iron pipe; well pit, 10 feet deep and 3 feet in diameter. *Strata:* Surface soil, 5 feet, and sand, 15 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. The wash water and soluble wastes from the house are carried by a tile drain pipe to the edge of the marsh some 4 rods distant.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Hay Creek, a small creek near back of house.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, unprotected vault.

Milk.—Sold in Red Wing; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

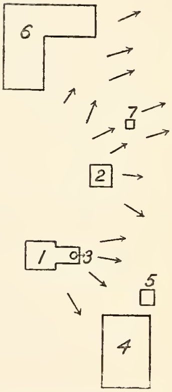

FIG. 56.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 10: 1, House; 2, ice house; 3, well; 4, stables; 5, milk house; 6, barn and stables; 7, privy.

No. 11. A good supply. This may, however, become polluted unless the well pit is kept clean and dry.

Location of farm.—Morris, Minn.

Date of visit.—August 10, 1908.

Size.—Two hundred and forty acres.

Kind of farming.—General.

Topography.—The well is about 1½ feet above house and stables. The general slope is away from the well in all directions.

Source of water supply.—(See fig. 57.) Well about 25 feet from stables; 182 feet in depth; casing, 2½-inch iron pipe. *Strata:* Clay, 70 feet, and gravel and sand, 112 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. The well pit, which is 12 feet deep and cased with boards, is used as a storage reservoir and is constantly over half full of water. The water from the pit is used for cattle only. There is always danger of a filled pit leaking into the well through defective casing. The covering is of loose boards.

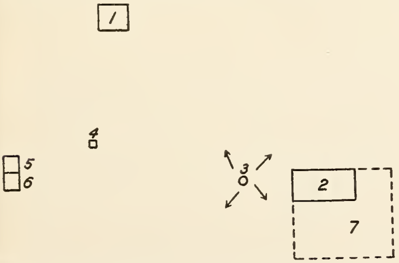

FIG. 57.—Sketch showing the topography and the location of buildings in the vicinity of driven well No 11: 1, House; 2, barn and stables; 3, well; 4, privy; 5, ice house; 6, tool shed; 7, barnyard.

Cisterns.—One, under house, used for washing and at times for drinking, but owner stated that they never drank this water unless it had been boiled.

Lakes, rivers, ponds, and springs.—Two ponds which contain water all the year.

Sanitary condition of farmhouse and outbuildings.—House excellent; stables good; privy poor, open vault and unprotected.

Milk.—Made into butter; sanitary care good.

Water-borne diseases.—One case of typhoid on this farm eighteen years previous to date of visit, but a different source of water supply was used at that time. No definite data could be obtained regarding the case.

Analyses.—See page 79.

No. 12. A good supply. This supply must be given exceptional care, especially against surface wash from the barnyard. The use of the well pit for refrigeration is inadvisable. It would be best to sink a well for domestic supply some distance from the barnyard and outbuildings.

Location of farm.—Henning, Minn.

Date of visit.—August 11, 1908.

Size.—One hundred and sixty acres.

Topography.—Perfectly level.

Source of water supply.—(See fig. 58.) Well 25 feet from house and 175 feet from stables at edge of barnyard; 24 feet in depth, 16 dug and 8 driven; casing, 2-inch boards in dug portion and 2-inch iron pipe in driven portion. *Strata:* Clay, 8 feet, and sand, 16 feet. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. As the number of animals cared for in the barnyard increases the well may become polluted. The covering is in poor condition; the planks are left loose so that they can be removed and pails of milk, etc., suspended in the well. On date of visit the dug portion contained several feet of water.

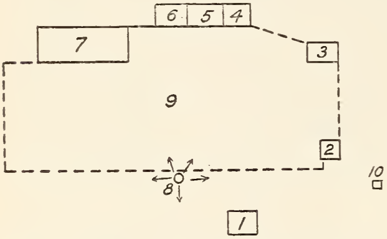

FIG. 58.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 12; 1, House; 2, tool shed; 3, granary; 4, hogpen; 5, wagon shed; 6, chicken house; 7, barn and stables; 8, well; 9, barnyard; 10, privy.

Cisterns.—One, used for washing.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; milk house excellent; privy poor, open vault and unprotected.

Milk.—Cream sold to butter factory; sanitary care good.

Water-borne diseases.—Two cases of typhoid fever have occurred on this farm; a girl, age 16, taken sick July 14, 1908, and a boy, age 14, taken sick July 25. The entire family, numbering seven persons, had attended two circuses a short time previous to the infection of the first case. The first circus attended was at Wadena, Minn., June 27, on which occasion all the family drank water from several sources in Wadena as well as on the train, and also drank circus lemonade. The second circus was at Henning, July 10; on this occasion both of the infected people drank water from several sources in Henning. Judging from the date of the first appearance of the infection, it would seem reasonable to think the disease was contracted at Wadena. The second case might have been infected from the original source, but more probably was infected from the first case.

Analyses.—See page 79.

No. 13. A polluted supply. This may be due to bad water used for priming, but is more probably due to a too rapid inflow from the river. Sinking a well at a greater distance from the river and installing a good pump would give a good supply.

Location of farm.—Crookston, Minn.
Date of visit.—September 11, 1908.
Size.—Three hundred and twenty acres.
Kind of farming.—Grain.
Topography.—Surface very broken; slope in direction of Red Lake River. Elevation of principal buildings about 25 feet above river.
Source of water supply.—(See fig. 59.) Well about 25 feet from Red Lake River, surface elevation about 20 feet above bed of river; 12 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sand, 4 feet; clay, 4 feet; and sand, 4 feet. *Yield:* Insufficient. *Use:* Drinking and general farm purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. Far enough from buildings to be safe from such pollution and surface well protected except for priming the pump. This well may receive a direct flow from the river, as the water supply follows very closely its rise and fall.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—Red Lake River flows through farm and is used for drinking and other purposes.
Sanitary condition of farmhouse and outbuildings.—House good; stables very poor; privy poor, open vault and unprotected.
Milk.—Cream sold to butter factory; sanitary care fair.
Water-borne diseases.—Two cases of typhoid fever occurred on this farm in the spring of 1908, a girl 19 years old taken sick February 10, and a boy 13 years old taken sick March 10. The first patient had not been away from the farm for at least six weeks previous to the infection, as during the cold weather the people in this back country move about very little. The water used in the winter for drinking purposes is taken from the Red Lake River and no well water is used. The second patient had been around the neighborhood but not to any adjoining towns during the period of infection. The physician and family lay the source of infection to the river water, and judging from other cases in the same vicinity this is undoubtedly the source. The second case might be contact or from the original source, the river, for the family drank the river water until February 25.

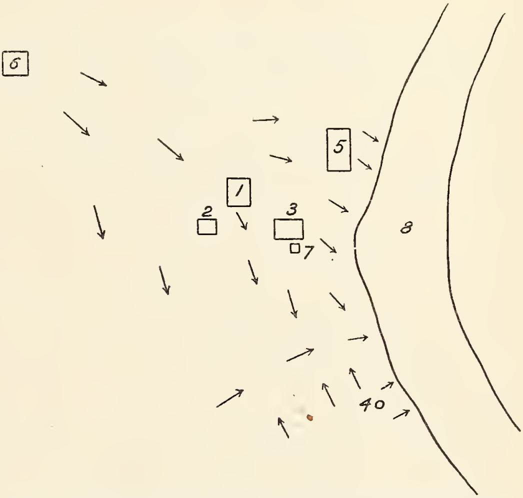

FIG. 59.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 13: 1, House; 2, granary; 3, hogpen; 4, well; 5, stables; 6, granary; 7, privy; 8, Red Lake River.

Analyses.—See page 79.

No. 14. A polluted supply. Thorough surface protection might make this a good supply. It would be better, however, to sink a well farther from the stable and barnyard.

Location of farm.—Crookston, Minn.

Date of visit.—September 11, 1908.

Size.—One hundred and sixty acres.

Kind of farming.—Grain.

Topography.—Level prairie.

Source of water supply.—(See fig. 60.) Well about 5 feet from stable; 25 feet in depth, dug 20 feet and driven 5 feet; casing, 1½-inch pipe. *Strata:* Blue prairie clay. *Yield:* Insufficient during dry season. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The poor covering allows surface wash to enter. The dug portion contains several feet of water and gives off a bad odor when cover is removed. From the color of the pump water it is evident that this offensive water from the dug portion reaches the well proper.

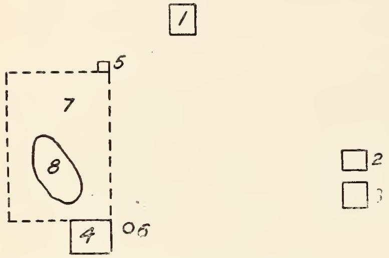

FIG. 60.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 14: 1, House; 2, granary; 3, granary; 4, stables; 5, privy; 6, well; 7, barnyard; 8, pond.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—One pond in barnyard.

Sanitary condition of farmhouse and outbuildings.—House very poor; stable very poor; privy very poor, open vault and unprotected.

Milk.—Made into butter; sanitary care very poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 15. A good supply.

Location of farm.—Gladstone, Minn.

Date of visit.—July 20, 1908.

Size.—Forty acres.

Kind of farming.—General.

Topography.—The ground surrounding house and outbuildings is level with the exception of a slight incline near shore of lake. House is about 1½ feet above lake.

Source of water supply.—(See fig. 61.) Well 3 feet from house and 35 feet from lake; 65 feet in depth; casing, 1½-inch iron pipe; well pit, 10 feet deep, in good, dry condition. *Strata:* Unknown. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Round Lake, a small circular lake probably 40 rods at greatest width.

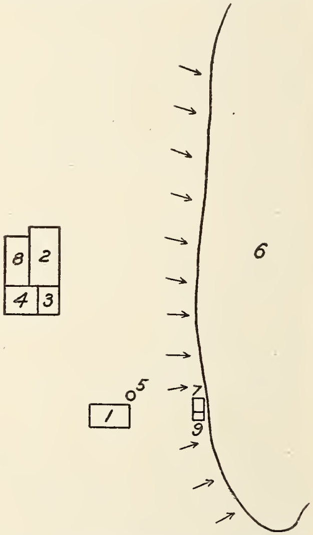

FIG. 61.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 15: 1, House; 2, stables; 3, stables; 4, wagon shed; 5, well; 6, Round Lake; 7, wood shed; 8, stable; 9, privy.

Sanitary condition of farmhouse and outbuildings.—House good; stables good; privy, open vault and unprotected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 16. A good supply. The location of this supply is too near the house and privy, yet the natural sand filter will keep it safe under the existing conditions. Improved surface protection is advisable, especially if the draft upon the well is increased.

Location of farm.—Anoka, Minn.
Date of visit.—September 29, 1908.
Size.—One hundred and eighty acres.
Kind of farming.—General.
Topography.—Level ground of a sandy surface character. Surface adjacent to house is artificially elevated about 1 foot above surrounding ground. Drainage in all directions away from house and well.
Source of water supply.—(See fig. 62.) Well about 5 feet from house; 36 feet in depth, dug 28 feet and driven 8 feet; casing, dug portion bricked, driven portion 1½-inch iron pipe. *Strata:* Sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Fair. Privy 50 feet away on slightly lower ground. Back flow from pump enters dug portion of well. Covering in poor condition.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—Round Lake touches one side of farm, and a small river, outlet to the lake, flows through part of farm.
Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy very poor, open vault and unprotected.

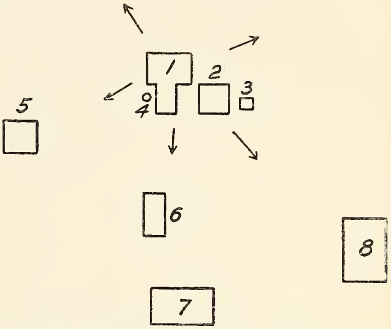

FIG. 62.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 16; 1, House; 2, ice house; 3, privy; 4, well; 5, wagon shed; 6, chicken coop; 7, hay barn; 8, stables.

Milk.—Sold to creamery; sanitary care good.
Water-borne diseases.—None recorded.
Analyses.—See page 79.

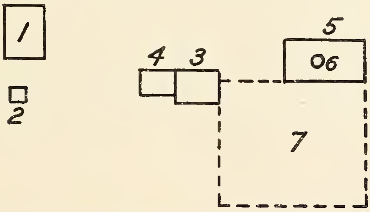

FIG. 63.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 17: 1, House; 2, privy; 3, granary; 4, wagon shed; 5, stables; 6, well; 7, barnyard.

No. 17. A good supply. The surroundings are very unsanitary, and although the natural filtration of the upper strata may protect the water indefinitely it would be advisable to sink a well in a better place for domestic use.

Location of farm.—Anoka, Minn.
Date of visit.—September 29, 1908.
Size.—One hundred and forty-five acres.
Kind of farming.—General.
Topography.—Level prairie; surface soil sandy.
Source of water supply.—(See fig. 63.) Well in farm barn; 40 feet in depth; casing, 1½-inch iron pipe. *Strata:* Sand. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron cistern pump. *Sanitary aspect:* Bad. Well is located in stable directly between the horse and cow stalls, and the drainage from the dirt floor of the stables forms a puddle around the well pipe.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—Several ponds, permanent throughout the year.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Cream shipped to St. Paul; sanitary care very poor.

Water-borne diseases.—One case of typhoid. The patient, a man 38 years old, was taken sick October 10, 1907, while repairing the public road near his house. Previous to his illness he drank water at several of the neighboring wells, though no other cases of typhoid developed in the neighborhood. On September 19, 20, and 21 the patient attended a street fair at Anoka and drank water from the city fountain several times. Several cases of typhoid were present in the city of Anoka and were supposed to have derived their infection from the city supply. The water supply of Anoka is taken from the Rum River, which has been found to be polluted.[a] One of the State insane asylums is located a short distance above the city and turns its sewage into the river after partial purification.

Analyses.—See page 79.

No. 18. A good supply. This supply will eventually become polluted unless the mouth and well pit are given better protection against surface wash and drainage from the upper strata.

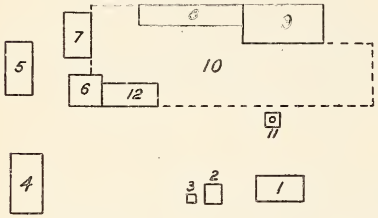

FIG. 64.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 18: 1, House; 2, wood shed; 3, privy; 4, tool shed; 5, tool shed; 6, granary; 7, hogpen; 8, stables; 9, barn and stables; 10, barnyard; 11, well; 12, tool shed.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

Size.—Two hundred acres.

Kind of farming.—General.

Topography.—Level prairie; sandy surface. Artificial drainage in several directions.

Source of water supply.—(See fig. 64.) Well in pump house; 28 feet in depth; casing, 1½-inch iron pipe; well pit 10 feet deep, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad, located at edge of barnyard. Drinking tank for cattle about 5 feet from well and surrounded by mud. Well pit contains about 1 foot of water as back flow and surface wash.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House poor; stables poor; privy poor, open vault and unprotected.

Milk.—Cream retailed in Anoka; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 19. A good supply. This supply is in danger of becoming polluted by seepage from the well pit. A good covering should be installed, and a drain ditch should lead off the water from the cattle trough.

Location of farm.—Anoka, Minn.

Date of visit.—September 29, 1908.

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[a] Determination made by Minnesota State Board of Health.

Size.—Thirty acres.

Kind of farming.—General.

Topography.—Level ground of a sandy surface type. Drainage in no special direction.

Source of water supply.—(See fig. 65.) Well about 40 feet from house; 25 feet in depth; casing, 1½-inch iron pipe; well pit 10 feet deep, cased with wood. *Strata:* Sand and gravel. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump, windmill used for power. *Sanitary aspect:* Fair. Well about 30 feet from barnyard. Watering trough for cattle a few feet from well and surrounded by mud. Covering in very poor condition, so back flow from pump enters freely. Well pit contains several inches of water.

Cisterns.—None.

Lakes, rivers, ponds, and springs.—None.

Sanitary condition of farmhouse and outbuildings.—House good; stables poor; privy poor, open vault and unprotected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

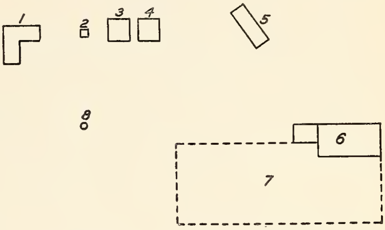

FIG. 65.—Sketch showing the topography and the location of buildings in the vicinity of driven well No. 19: 1, House; 2, privy; 3, tool shed; 4, corncrib; 5, chicken house; 6, barn and stables; 7, barnyard; 8, well.

SPRINGS.

No. 1. A polluted supply. This supply could be made safe and attractive by proper protection against water from the surface and upper strata. The privy should be moved to a greater distance and preferably to a lower level.

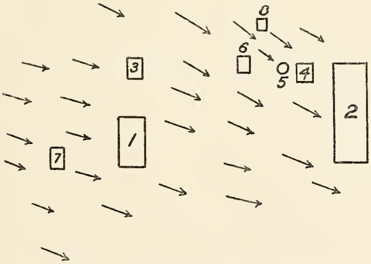

FIG. 66.—Sketch showing the topography and the location of buildings in the vicinity of spring No. 1: 1, House; 2, barn and stables; 3, wood shed; 4, milk house; 5, spring; 6, tool shed; 7, outdoor kitchen; 8, privy.

Location of farm.—Minneapolis, Minn.

Date of visit.—July 8, 1908.

Size.—Thirty-five acres.

Kind of farming.—Dairy.

Topography.—The surface slopes from house and outbuildings toward the barn; a difference in elevation of about 8 feet. The land on the opposite side of the barn from the house is low and marshy.

Source of water supply.—(See fig. 66.) Spring on sloping ground surrounded by outbuildings; dug down about 10 feet and cased with wood. *Yield:* Abundant. *Use:* Drinking and general farm purposes. *Sanitary aspect:* Bad. The spring is so located that with care good water could be secured; unfortunately, however, the privy is only about 20 feet away and the spring is poorly protected.

Cisterns.—None.

Lakes, rivers, ponds, and wells.—None.

Sanitary condition of farmhouse and outbuildings.—House good; outbuildings fair; privy poor, unprotected vault.

Milk.—Retailed in Minneapolis; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 2. For a description of this spring, see cistern No. 3, under the heading "Lakes, rivers, ponds, and springs," page 66.

RIVERS.

No. 1. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

The main supply for this farm is a dug well, although the river water has been used during the winter season. For description, see No. 26, under the heading "Dug wells."

No. 2. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

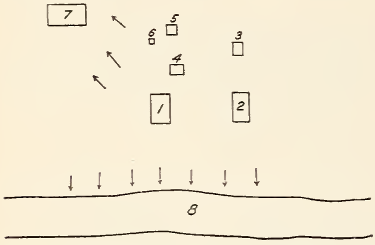

FIG. 67.—Sketch showing the topography and the location of buildings in the vicinity of river No. 2: 1, House; 2, blacksmith shop; 3, chicken house; 4, wood shed; 5, chicken house; 6, privy; 7, stable; 8, Red Lake River.

Location of farm.—Huot, Minn.
Date of visit.—September 11, 1908.
Size.—One acre.
Kind of farming.—General.
Topography.—Drainage from the farm buildings is chiefly away from the river.
Source of water supply.—(See fig. 67.) Well; see report No. 26 under "Dug wells" for description of well which was also used by this family.
Cisterns.—None.
Lakes, rivers, ponds, and springs.—Red Lake River forms the southern boundary of the property and served as a water supply during the winter until typhoid fever developed.
Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor. privy very poor, open vault entirely unprotected.
Milk.—Used on farm; sanitary care very poor.
Water-borne diseases.—Three cases of typhoid fever occurred on this place during February, March, and April, 1908. The first, a boy 10 years old, was taken sick about February 15; the second, a man 40 years old, February 28, and the third, a boy 7 years old, April 19. All of these people drank river water from the Red Lake River from September 30 until March 15, on which date the doctor in charge decided the river water to be the source of infection.
Analyses.—See page 79.

No. 3. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

Location of farm.—Thief River Falls, Minn.
Date of visit.—September 14, 1908.
Size.—Seventy-seven acres.
Kind of farming.—General.
Topography.—House and outbuildings 20 feet above Red Lake River. Entire drainage from yards is in direction of river.

Source of water supply.—(See fig. 68.) Red Lake River.
Cisterns.—None.
Lakes, wells, ponds, and springs.—None.
Sanitary condition of farmhouse and outbuildings.—House very poor; stables very poor; privy very poor, open vault and unprotected. This is a typical pioneer residence. The property was formerly part of the Red Lake Indian Reservation and has recently been taken up by settlers.
Milk.—Sold to creamery; sanitary care very poor.
Water-borne diseases.—None recorded.
Analyses.—See page 79.

No. 4. A polluted supply. It is impracticable to try to purify polluted river water for farm use. Wells should be used for the domestic supply at least.

The main supply for this farm is a driven well, although the river water has been used during the winter season. For description, see No. 13, under the heading "Driven wells."

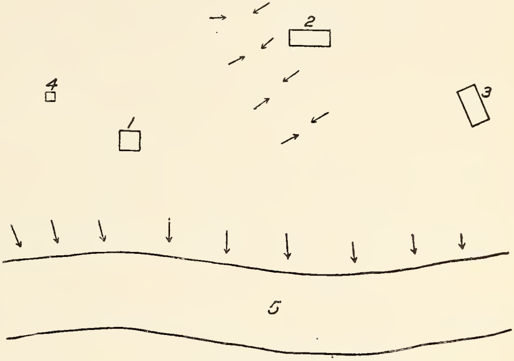

FIG. 68.—Sketch showing the topography and the location of buildings in the vicinity of river No. 3: 1, House; 2, chicken house; 3, stables; 4, privy; 5, Red Lake River.

SURFACE RESERVOIRS.

No. 1. For a description of this reservoir, see cistern No. 1, under the heading "Lakes, rivers, ponds, and springs," p. 64.

No. 2. For a description of this reservoir, see cistern No. 2, under the heading "Lakes, rivers, ponds, and springs," p. 65.

CISTERNS.

No. 1. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

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[a] Moore, G. T., and Kellerman, K. F. Methods of Destroying or Preventing the Growth of Algæ and Certain Pathogenic Bacteria in Water Supplies. Bureau of Plant Industry, Bul. 64. 1904.

Kraemer, Henry. The Copper Treatment of Water. American Journal of Pharmacy, vol. 76, No. 12, pp. 574–579. 1904.

Lewis, Frank C. The Sterilization of Water. Public Health Engineering, vol. 16, No. 415, p. 350. London, 1905.

Maignen, P. A. Different Methods of Purifying Water. Proceedings of the Engineers' Club of Philadelphia, vol. 24, No. 1, pp. 1–69. 1907.

Location of farm.—Kennedy, Minn.

Date of visit.—September 15, 1908.

Size.—Twelve thousand acres.

Kind of farming.—General and grain.

Topography.—Farm buildings located on level prairie land.

Source of water supply.—(See fig. 69.) Cistern under farmhouse kitchen. *Type:* Dug, with brick casing lined with cement; circular, with conical arched roof. *Capacity:* Two hundred barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. There are two openings, a circular manhole at the top and a small 4-inch opening in the side near the roof. The manhole is well protected with a tight board cover. A small well-protected pipe for carrying water into the cistern leads to the opening in the side, which pipe affords the only means of ventilation. An odor was complained of which could possibly be eliminated by better ventilation.

Lakes, rivers, ponds, and springs.—A second source of water supply for this farm is a shallow surface reservoir. This reservoir was scooped out of the surface soil and allowed to fill with surface water during the spring season, and it constitutes a supply for general farm use. It is about 60 feet long and 40 feet wide. The water is partly filtered by being passed to a well pit through a ditch dug in the clay and filled with gravel; however, this improves the condition of the water very little. The water is pumped from the well pit. The sanitary aspect is very bad; the water is entirely unprotected and is grossly polluted. On the date of visit it contained a large quantity of vegetable growth.

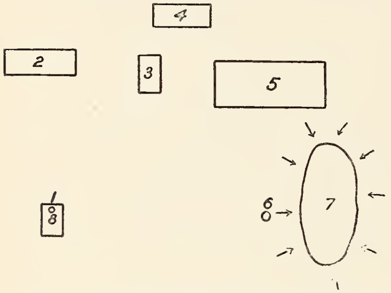

FIG. 69.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 1: 1, House; 2, granary; 3, wagon shed; 4, feed house; 5, barn and stables; 6, well pit; 7, reservoir; 8, cistern.

Sanitary condition of farmhouse and outbuildings.—House good; stables very good; privy good, open vault well protected.

Milk.—Used on farm; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 2. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Kennedy, Minn.

Date of visit.—September 15, 1908.

Size.—One thousand acres.

Kind of farming.—General and grain.

Topography.—Level prairie land.

Source of water supply.—(See fig. 70.) Cistern under kitchen of farmhouse. *Type:* Dug, with brick casing lined with cement; circular, with conical arched roof. *Capacity:* One hundred and fifty barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Cistern pump. *Sanitary aspect:* Fair. Surface in good condition and opening for entrance of water well protected.

Lakes, rivers, ponds, and springs.—A surface reservoir is used for an additional supply for cattle, and in case of necessity for drinking. It is dug in clay soil, and its approximate dimensions are 60 feet long, 35 feet wide, and 6 feet deep. It is allowed to fill with surface water during the winter and spring, and the heavy clay soil holds the water throughout the summer. The sanitary conditions surrounding this supply are very bad. Surface wash from the barnyard enters freely; decaying vegetable growths could be seen in water on date of visit. The water is pumped directly from the reservoir by means of a wooden pump suspended on a platform built over the water. These surface water supplies are necessarily used on account of the impracticability of a deep ground supply or of a surface well. The deep ground waters of this area are very salty and in most cases have a strong alkaline taste, which renders them impossible for domestic or farm use.

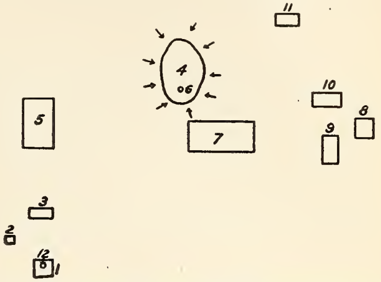

FIG. 70.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 2: 1, House; 2, privy; 3, wood shed; 4, reservoir; 5, tool shed; 6, pump; 7, barn and stables; 8, granary; 9, chicken coop; 10, granary; 11, hogpen; 12, cistern.

Sanitary condition of farmhouse and outbuildings.—House very good; stables very good; privy good, open vault well protected.

Milk.—Used by family; sanitary care very good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 3. A polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

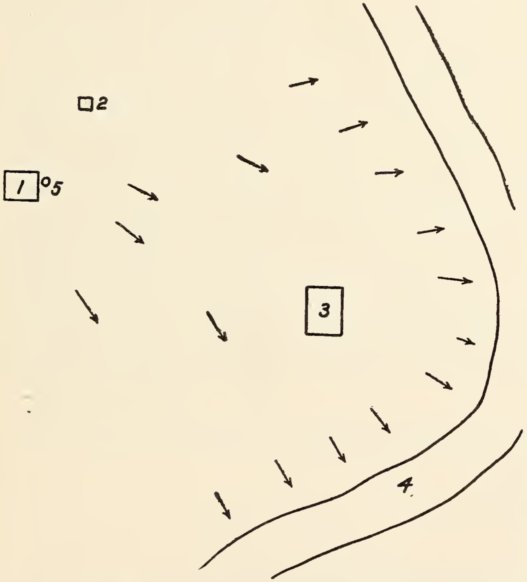

FIG. 71.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 3: 1, House; 2, privy; 3, stables; 4, creek; 5, cistern.

Size.—Two hundred and forty acres.

Kind of farming.—General.

Topography.—Surface undulating; buildings on banks of creek; house about 5 feet higher than barn, 30 feet higher than creek.

Source of water supply.—(See fig. 71.) Cistern at side of house. *Type:* Dug, with galvanized iron casing; circular, with flat top. *Capacity:* Sixty barrels. *Use:* Drinking and general farm purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Good. Cistern appears to be well protected in every way; surface of galvanized tank tightly covered with boards; top projects some few feet above surface of ground and thus eliminates all danger of surface water entering.

Lakes, rivers, ponds, and springs.—An interesting feature on this farm is a salt spring. It is very troublesome, as it flows into a small creek near the farm buildings and completely ruins the water for all farm purposes. The flow is probably no more than several barrels an hour, but even this small quantity is sufficient to impart a bad taste to the creek water. This spring water is quite similar in taste and appearance to the water in the few wells in that vicinity. A sample was collected for the purpose of studying the character of these disagreeable ground waters of the Red River Valley district.

Sanitary condition of farmhouse and outbuildings.—House good; stables fair; privy poor, open vault entirely unprotected.

Milk.—Made into butter; sanitary care good.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

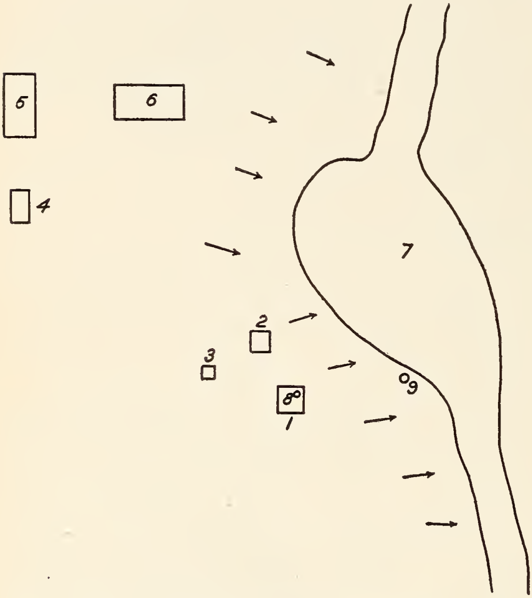

Fig. 72.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 4: 1, House; 2, ice house; 3, privy; 4, tool shed; 5, stables; 6 granary; 7, creek; 8, cistern; 9, well.

No. 4. This is a badly polluted supply. The roof is the source of pollution, and unless sufficient water for a thorough rinsing of the roof can be wasted at the beginning of each rain it will be impossible to improve the water supply. Under such conditions the water for drinking should be boiled or otherwise disinfected.

Location of farm.—Hallock, Minn.

Date of visit.—September 16, 1908.

Size.—Six hundred and forty acres.

Kind of farming.—Grain.

Topography.—Drainage from the farm buildings flows in the direction of the creek.

Source of water supply.—(See fig. 72.) Two cisterns in cellar of house. *Type:* Galvanized iron tanks; circular, with flat bottoms. *Capacity*: One hundred barrels each. *Use:* Drinking and general house purposes. *Method of lifting:* Water dipped from tanks with pails. *Sanitary aspect:* Poor. The tanks were in excellent condition, but lacked coverings to protect them from dust and such other material as might fall from the floor above. The tin pipe leading from roof to tanks is provided with a sort of filter, consisting of a rectangular tin box 12 inches by 5 inches by 5 inches, with a conical bottom. Bags of charcoal the proper size to fit this box are placed in it, and the water in flowing to the tanks must necessarily pass through this filter. The bags are removed after each rain and replaced by clean bags of the same material.

Lakes, rivers, ponds, and springs.—One creek.

Sanitary condition of farmhouse and outbuildings.—House fair; stables fair; privy poor, open vault, entirely unprotected.

Milk.—Made into butter; sanitary care fair.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

No. 5. A polluted supply. The cistern needs a thorough cleaning. With proper covering the condition of the cistern could be improved, and by wasting the first rinsing from the roof at the beginning of each rain the water might be kept in good condition.

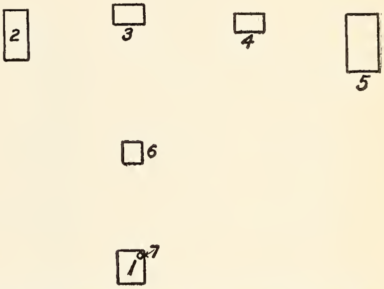

FIG. 73.—Sketch showing the topography and the location of buildings in the vicinity of cistern No. 5: 1, House; 2, granary; 3, tool shed; 4, hogpen; 5, stables; 6, wood shed and privy; 7, cistern.

Location of farm.—Hallock, Minn.

Date of visit.—September 17, 1908.

Size.—Four hundred and eighty acres.

Kind of farming.—Grain.

Topography.—Level prairie land.

Source of water supply.—(See fig. 73.) Cistern under kitchen. *Type:* Dug, with brick casing lined with cement; round, with conical roof. *Capacity:* One hundred barrels. *Use:* Drinking and general house purposes. *Method of lifting:* Iron pump. *Sanitary aspect:* Bad. The covering is in very poor condition and the water has a strong odor of decaying organic matter.

Lakes, rivers, ponds, and springs.—Several ponds have been dug to collect water for watering cattle.

Sanitary condition of farmhouse and outbuildings.—House very poor; stables good; privy poor, open vault, entirely unprotected.

Milk.—Made into butter; sanitary care poor.

Water-borne diseases.—None recorded.

Analyses.—See page 79.

TABULATION OF SANITARY SURVEYS.

The following tables give full information in regard to the sanitary surveys, including analyses:

TABLE I.—*Location, size, and other details of farms in Minnesota on which an investigation of water supplies was made.*

DUG WELLS.

No.	Location.	Date of visit.	Size.	Kind of farming.	Topography.	
					Character of surface.	Drainage.
		1908.	*Acres.*			
1	Merriam Park	July 3	80	General	Rolling	Fair.
2	Minneapolis	July 8	36	Dairy	Level	Poor.
3	St. Paul	July 16	12	do	Undulating	Good.
4	do	do	140	General	do	Do.
5	do	July 17	160	do	Irregular	Fair.
6	Gladstone	July 20	13	do	do	Good.
7	do	July 18	75	Dairy	Rolling	Do.
8	Hastings	July 22	120	General	do	Poor.
9	do	do	40	Dairy	Level	Fair.
10	Red Wing	July 23	103½	do	Rolling	Poor.
11	do	July 24	3	General	Irregular	Do.
12	Mankato	July 28	120	Dairy	Level	Do.
13	do	do	28	do	do	Do.
14	do	do	65	do	do	Do.
15	Owatonna	July 30	200	do	do	Good.
16	do	do	136	General	Rolling	Poor.
17	Austin	Aug. 1	640	do	Level	Do.
18	do	do	80	do	do	Fair.
19	Oakland	do	70	do	do	Poor.
20	do	do	235	do	do	Do.
21	Rochester	Aug. 4	160	do	Rolling	Good.
22	South Haven	Aug. 14	150	do	Irregular	Do.
23	St. Cloud	do	248	do	Level	Poor.
24	Sauk Center	Aug. 17	160	Grain	do	Do.
25	Crookston	Sept. 10	160	do	do	Do.
26	Huot	Sept. 11	2	General	Irregular	Fair.
27	Thief River Falls	Sept. 14	145	Grain	Level	Poor.
28	Hallock	Sept. 16	320	General	do	Fair.

BORED WELLS.

1	Chikio	Aug. 10	160	General	Level	Poor.
2	Sauk Center	Aug. 17	120	do	do	Do.
3	Argyle	Sept. 12	160	Grain	do	Fair.
4	do	do	160	do	do	Do.

DRILLED WELLS.

1	Red Wing	July 24	18	Dairy	Irregular	Good.
2	St. Peter	July 27	120	General	Level	Poor.
3	Owatonna	July 30	160	do	do	Fair.
4	do	do	240	do	Rolling	Good.
5	Rochester	Aug. 4	185	do	do	Fair.
6	Alexandria	Aug. 12	141	do	Irregular	Do.
7	do	do	220	do	do	Good.
8	Sauk Center	Aug. 17	330	do	Rolling	Do.
9	Crookston	Sept. 10	240	Grain	Level	Poor.
10	do	do	320	do	do	Do.
11	do	do	160	do	do	Do.
12	Hallock	Sept. 17	480	do	do	Do.
13	Anoka	Sept. 29	230	General	do	Fair.

TABLE I.—*Location, size, and other details of farms in Minnesota on which an investigation of water supplies was made*—Continued.

DRIVEN WELLS.

No.	Location.	Date of visit.	Size.	Kind of farming.	Topography.	
					Character of surface.	Drainage.
		1908.	*Acres.*			
1	Excelsior	June 30	140	General	Irregular	Good.
2	New Brighton	July 3	40	do	Rolling	Fair.
3	St. Louis Park	July 6	60	Dairy	Irregular	Poor.
4	Minneapolis	July 8	180	do	Undulating	Do.
5	Richfield	July 10	90	do	Rolling	Do.
6	Minneapolis	do	230	General	Level	Do.
7	St. Paul	July 15	3	Dairy	do	Do.
8	do	do	10	do	Irregular	Do.
9	do	July 17	80	do	Undulating	Fair.
10	Red Wing	July 23	70	do	do	Do.
11	Morris	Aug. 10	240	General	Level	Do.
12	Henning	Aug. 11	160	do	do	Poor.
13	Crookston	Sept. 11	320	Grain	Irregular	Good.
14	do	do	160	do	Level	Poor.
15	Gladstone	July 20	40	General	do	Good.
16	Anoka	Sept. 29	180	do	do	Do.
17	do	do	145	do	do	Poor.
18	do	do	200	do	do	Fair.
19	do	do	30	do	do	Poor.

SPRINGS.

1	Minneapolis	July 8	35	Dairy	Irregular	Poor.
2	Hallock	Sept. 16	240	General	Undulating	Good.

RIVERS.

1	Huot	Sept. 11	2	General	Irregular	Fair.
2	do	do	1	do	do	Do.
3	Thief River Falls	Sept. 14	77	do	Level	Do.
4	Crookston	Sept. 11	320	Grain	Irregular	Do.

SURFACE RESERVOIRS.

1	Kennedy	Sept. 15	12,000	Grain	Level	Fair.
2	do	do	1,000	do	do	Do.

CISTERNS.

1	Kennedy	Sept. 15	12,000	Grain	Level	Fair.
2	do	do	1,000	do	do	Do.
3	Hallock	Sept. 16	240	General	Undulating	Good.
4	do	do	640	Grain	Irregular	Do.
5	do	Sept. 17	480	do	Level	Poor.

TABLE II.—*Local and structural details concerning the water supplies in Minnesota of which an investigation was made.*

DUG WELLS.

No.	Character of location.	Depth.	Strata.	Casing.	Yield.	Use.	Means of lifting.		Other water on farm.
							Method.	Power.	
		Feet.							
1	Poor	28	Clay, 23 feet; sand, 5 feet	Brick	Insufficient	Drinking and general farm purposes.	Iron pump	Hand	Cistern.
2	do	15	Soft marsh soil	Wood	Abundant	do	do	do	Ponds.
3	Good	80	Unknown	do	do	do	do	Windmill	None.
4	Poor	38	Clay, 28 feet; sandy gravel, 10 feet.	do	Insufficient	do	Rope and bucket	Hand	Ponds.
5	do	25	Clay	Tile, 12-inch	Abundant	do	Wooden pump	do	Cistern.
6	Fair	22	Clay, 9 feet; sand, 13 feet	Wood	do	do	Rope and bucket	do	Lake, creek.
7	do	20	Gravel and clay	do	do	do	Iron pump	Windmill	Ponds.
8	Poor	18	Gravel	Stone	do	do	do	Hand	Cistern.
9	Good	127	Sand and gravel mixed	Tile, 6-inch	do	do	do	Windmill	Do.
10	Poor	15	Black marsh soil	Stone	do	do	Rope and bucket	Hand	Creek, springs.
11	do	10	Surface soil and sand	None	do	do	Iron pump	do	None.
12	do	25	Sand, clay, and gravel mixed	Stone	do	do	do	do	Springs, ponds, cistern.
13	do	12	Clay, 8 feet; gravel, 4 feet	do	Insufficient	do	do	do	Ponds.
14	do	27	Surface soil and blue clay	do	do	do	do	do	Cistern, ponds.
15	do	40	Blue clay	do	Abundant	do	do	do	Cistern.
16	do	30	Unknown	do	do	do	do	Windmill	Do.
17	do	60	Yellow clay	Tile	do	do	do	do	Do.
18	Good	28	Surface soil, 2 feet; sand, 8 feet; hardpan, 4 feet; sand, 6 feet; rock, 8 feet.	Wood	do	do	do	Hand	None.
19	Poor	12	Gravel, blue clay, quicksand	Tile, 2-foot	do	do	Wooden pump	do	Do.
20	do	30	Surface soil, 3 feet; rest clay	Stone	do	do	Iron pump	do	Do.
21	Fair	30	Surface soil, 3 feet; clay, 10 feet; gravel 17 feet.	do	do	do	do	do	Cistern.
22	Poor	14	Clay, 13 feet; gravel and sand, 1 foot.	Wood	do	do	do	do	Pond.
23	Fair	44	Hardpan, clay, gravel; sand	Brick	do	do	do	do	None.
24	do	25	Clay and sand	Wood	do	do	Wooden pump	do	Do.
25	do	40	Blue clay	do	do	do	do	do	Do.
26	Poor	12	Sand, gravel, and clay	do	do	do	Iron pump	do	River.
27	Fair	13	Blue clay	do	do	do	Rope and bucket	do	None.
28	Good	18	Loam 2 feet; yellow clay, 5 feet; gravel, sand, and clay, 6 feet; hardpan, 5 feet.	Brick and wood.	Insufficient	do	do	do	River.

BORED WELLS.

1	Poor	55	Clay, 40 feet; sand and gravel, 15 feet.	Wood	Abundant	Drinking and general farm purposes.	Iron pump	Hand	None.
2	do	27	Clay and sand	None	do	do	Wood pump	do	Do.
3	Fair	10	Blue prairie clay	Tin, 6-inch	Insufficient	Drinking	Rope and bucket	do	River.
4	do	13	do	do	Abundant	do	do	do	None.

DRILLED WELLS.

No.	Character of location.	Depth.	Strata.	Casing.	Well pit.		Yield.	Use.	Means of lifting.		Other water on farm.
					Depth.	Casing.			Method.	Power.	
		Feet.			*Feet.*						
1	Poor	138	Clay, 17 feet; rest limestone.	Iron pipe, 6-inch, and rock.			Abundant	Drinking and general farm purposes.	Iron pump	Horse	Cisterns.
2	do	167	Clay and sand	Iron, 2-inch	25	Stone	do	do	do	Windmill	Do.
3	Good	100	Blue clay and rock	Iron pipe, 6-inch.	40	do	do	do	do	Hand	Well, cistern.
4	Poor	90	Clay, 40 feet; rest gravel, sand	do	10	Wood	do	do	do	Windmill	Cistern.
5	do	60	Sand and clay, 30 feet; limestone, 30 feet.	Iron pipe, 3-inch.	30	Stone	do	do	do	do	Do.
6	Good	80	Gravel, 10 feet; red clay, 10 feet; blue clay, 50 feet; sand and gravel, 10 feet.	do			do	do	do	Hand	Lake, creek, spring.
7	Poor	60	Clay and sand	Iron			do	do	do	do	Cistern, ponds.
8	Good	153	Yellow clay, 30 feet; hardpan, 12 feet; sand, 15 feet; clay, 90 feet; sand, 6 feet.	Iron, 4-inch	10	Wood	do	do	do	Windmill	None.
9	do	200	Blue clay throughout	Iron, 2-inch			do	do	do	do	Cistern.
10	do	180	Unknown	do	14	Iron, 2½-feet.	do	do	do	Hand	None.
11	Fair	203	Blue clay, 20 feet; red clay, 150 feet; mixed sand and clay, 27 feet; rock, 3 feet; sand, 3 feet.	Iron, 2½-inch			do	do	do	do	Cistern.
12	Poor	75	Hardpan and clay mixture	do			Insufficient	do	do	Windmill	Ponds, cistern.
13	Good	112	Sand and gravel	Iron, 3-inch	10	Wood	Abundant	do	do	Gasoline engine.	None.

TABLE II.—*Local and structural details concerning the watersupplies in Minnesota of which an investigation was made*—Continued.

DRIVEN WELLS.

No.	Character of location.	Depth.	Strata.	Casing.	Well pit.		Yield.	Use.	Means of lifting.		Other water on farm.
					Depth.	Casing.			Method.	Power.	
		Feet.			*Feet.*						
1	Good	150	Surface clay, 10 feet; hardpan, 100 feet; gravel, 40 feet.	Iron, 3-inch	6	Brick	Abundant	Drinking and general farm purposes.	Iron pump	Gasoline engine and windmill.	Lake, creek, springs, and cistern.
2	Fair	160	Unknown	Iron pipe, 2-inch.	10	Wood	do	do	do	Windmill	Cistern.
3	Poor	60	do	do	10	do	do	do	do	do	Ponds.
4	do	20	Surface, 3 feet; sand, 17 feet	do	10	do	do	do	do	Gasoline engine	None.
5	do	50	Unknown	Iron, 1½-inch	10	do	do	do	do	Windmill	Cistern, lake.
6	do	40	Sandy soil	do	10	do	do	do	do	do	Do.
7	do	30	Unknown	do	8	do	do	do	do	do	None.
8	do	119	Sand, 25 feet; rest clay and gravel.	Iron, 2½-inch	7	do	do	do	do	Hand	Do.
9	Good	57	Clay, 50 feet; sand, 7 feet	Iron, 1½-inch	10	do	do	do	do	Windmill	Do.
10	Fair	20	Surface soil, 5 feet; sand, 15 feet.	Iron, 1¼-inch	10	do	do	do	do	Hand	Creek.
11	Good	182	Clay, 70 feet; gravel and sand, 112 feet.	Iron, 2½-inch	12	do	do	do	do	Windmill	Cistern, ponds.
12	Poor	24	Clay, 8 feet; sand, 16 feet	Iron, 2-inch	16	do	do	do	do	do	Cistern.
13	Good	12	Sand, 4 feet; clay, 4 feet; sand, 4 feet.	Iron, 1½-inch			Insufficient	do	Cistern pump	Hand	River.
14	Poor	25	Blue prairie clay	do	20	Wood	do	do	Iron pump	do	Pond.
15	Fair	65	Unknown	do	10	do	Abundant	do	do	do	Lake.
16	do	36	Sand	Iron, 1½-inch	28	Brick	do	do	do	do	River, lake.
17	Poor	40	do	do			do	do	Cistern pump	do	Ponds.
18	do	28	Sand and gravel	do	10	Wood	do	do	Iron pump	do	None.
19	Good	25	do	do	10	do	do	do	do	Windmill	Do.

SPRINGS.

No.	Character of location.	Character of surface around spring.	Spring pit.		Yield.	Use.	Means of lifting.		Other water on farm.
			Depth.	Casing.			Method.	Power.	
			Feet.						
1	Poor	Gravelly soil	10	Wood	Abundant	Drinking and general farm purposes.	Bucket	Hand	None.
2	do	Marshy soil	1	None	do	(Undrinkable)	do	do	Cistern, creek.

RIVERS.

No.	Locality.	Source.	Character of watershed.	Cities or villages on river above this farm.	Use.	Means of lifting.		Other water on farm.
						Method.	Power.	
1	Huot	Red Lake River	Large, flat area	About 6	Drinking and general farm purposes.	Bucket	Hand	Well.
2	do	do	do	do	do	do	do	None.
3	Thief River Falls	do	do	About 4	do	do	do	Do.
4	Crookston	do	do	About 7	do	do	do	Well.

SURFACE RESERVOIRS.

No.	Character of location.	Type.	Source of water.	Shape.	Size.	Casing.	Use.	Means of lifting.		Other water on farm.
								Method.	Power.	
					Feet.					
1	Poor	Dug	Rain	Oval	60 by 40 by 6	Clay	General farm purposes	Iron pump	Windmill	Cistern.
2	do	do	do	Rectangular	60 by 35 by 6	do	do	Wooden pump	Hand	Do.

TABLE II.—*Local and structural details concerning the water supplies in Minnesota of which an investigation was made*—Continued.

CISTERNS.

No.	Character of location.	Type.	Capacity.	Shape.	Casing.	Use.	Means of lifting.		Other water on farm.
							Method.	Power.	
			Barrels.						
1	Fair	Dug	200	Circular, arched top	Brick and cement	Drinking and general farm purposes.	Cistern pump	Hand	Surface reservoir.
2	do	do	150	do	do	do	do	do	Do.
3	Good	do	60	Circular, flat top	Galvanized iron	do	do	do	Spring and creek.
4	Fair	Tanks	200	do	do	do	Pail and rope	do	Creek.
5	Poor	Dug	100	Circular, conical roof	Brick and cement	do	Cistern pump	do	Ponds.

TABLE III.—*Sanitary and epidemiological data concerning the water supplies in Minnesota of which an investigation was made.*

DUG WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Milk.		Water-borne diseases.		
		House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Poor	Fair		Poor	Unprotected vault	Poor	Used on farm	None		
2	do	do		do	do	do	Sold	do		
3	do	do		Fair	do	do	do	Typhoid	1	Probably from St. Paul.
4	do	Poor		Poor	do	do	Used on farm	None		
5	Fair	Good		Good	do	Good	do	do		
6	Poor	Poor		Poor	do	No milk		Typhoid	1	Unknown.
7	Fair	Good	Fair	do	do	Fair	Sold	None		
8	do	do	Good	Good	Protected vault	Good	Cream sold	do		
9	do	do	do	do	do	do	Sold	do		
10	Poor	Good	Poor	Poor	Unprotected vault	Poor	do	do		
11	do	do		Good	do	Fair	Used on farm	do		
12	do	do	Good	do	do	Good	Sold	Typhoid	1	Mankato city water.
13	do	Fair		Poor	do	Poor	do	None		
14	Good	Good	Good	Good	Protected vault	Good	do	do		
15	Fair	do		do	Unprotected vault	do	Sold to creamery	do		
16	Poor	Poor		Poor	do	Poor	do	do		
17	do	Good	Fair	Good	do	Good	do	do		
18	Fair	do		Poor	do	Poor	Butter sold	do		
19	Poor	Poor		do	do	do	Sold	Typhoid	1	Unknown.
20	do	Fair		Good	do	Good	do	None		
21	Good	Good		do	Protected vault	do	do	do		
22	Poor	Poor		Poor	Unprotected vault	Poor	Butter sold	Typhoid	1	Do.
23	do	do		do	do	do	do	do	1	Do.
24	do	do		do	do	do	Sold	do	1	Do.
25	do	do		do	do	do	do	None		
26	do	Good		Fair	do	No milk		Typhoid	1	Red Lake River.
27	do	Poor		do	do	Poor	Butter sold	None		
28	do	do		do	do	do	do	do		

BORED WELLS.

No.	Sanitary aspect of supply.	House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Fair	Fair		Good	Unprotected vault	Fair	Sold	Typhoid	1	Unknown.
2	Poor	Poor		Poor	do	Poor	do	None		
3	do	Very poor		Very poor	do	do	Used on farm	Typhoid	6	Village of Oslo, Minn.
4	do	do		Good	do	do	do	None		

TABLE III.—*Sanitary and epidemiological data concerning the water supplies in Minnesota of which an investigation was made*—Continued.

DRILLED WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Milk.		Water-borne diseases.		
		House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Fair	Fair		Poor	Unprotected vault	Poor	Sold	None		
2	Poor	Good		Fair	do	Fair	do	Typhoid	3	Unknown.
3	Fair	Fair		do	do	do	do	do	1	Probably from neighbor.
4	Poor	Poor		Good	do	do	do	do	1	Unknown.
5	do	do	Poor	Poor	do	Poor	do	None		
6	Fair	Fair		Fair	do	do	do	do		
7	Poor	Poor		do	do	do	do	Typhoid	8	Do.
8	Good	Good		do	do	Good	do	None		
9	do	do		do	do	Fair	do	do		
10	Poor	Poor		do	do	Poor	Butter sold	Typhoid	2	Do.
11	Fair	do		Poor	do	Fair	do	None		
12	do	do		Good	do	Poor	do	do		
13	Good	Good	Good	do	Protected vault	Good	Cream sold	do		

DRIVEN WELLS.

No.	Sanitary aspect of supply.	Sanitary condition of farmhouse and outbuildings.				Milk.		Water-borne diseases.		
		House.	Milk house.	Stables.	Privy.	Sanitary care.	Disposal.	Disease.	Number of cases.	Source of infection.
1	Good	Good		Good	Modern	Good	Used on farm	None		
2	Fair	Fair		Poor	Unprotected vault	Poor	do	do		
3	Poor	Poor	Poor	do	do	do	Sold	do		
4	do	do	do	Fair	do	Fair	do	do		
5	do	Fair	do	Poor	do	Poor	do	Typhoid	3	City of Minneapolis.
6	Good	Good		Good	Protected vault	Good	Used on farm	None		
7	Poor	Poor	Fair	Fair	Unprotected vault	Fair	Sold	do		
8	Fair	do	Poor	do	do	Poor	do	do		
9	Good	Good	Good	Poor	do	Good	do	do		
10	do	do		do	do	do	do	do		
11	Fair	do		Good	do	do	Butter sold	Typhoid	1	Unknown.
12	do	do	Good	do	do	do	Cream sold	do	2	Circus at Wadena, Minn.
13	do	do		Poor	do	Fair	Sold	do	2	Red Lake River water.
14	Poor	Poor		do	do	Poor	Butter sold	None		
15	Good	Good		Good	do	Fair	Used on farm	do		
16	Fair	do		Fair	do	Good	Sold	do		
17	Poor	Poor		Poor	do	Poor	Cream sold	Typhoid	1	Rum River water.
18	do	do		do	do	do	do	None		
19	Fair	Good		do	do	Good	Used on farm	do		

SPRINGS.

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1	Poor	Good		Fair	Unprotected vault	Fair	Sold	None		
2	do	do		do	do	Good	Butter sold	do		

RIVERS.

1	Poor	Good		Fair	Unprotected vault	No milk		Typhoid	1	Red Lake River.
2	do	Poor		Poor	do	Poor	Used on farm	do	3	Do.
3	do	do		do	do	do	Sold	None		
4	do	Good		do	do	Fair	do	Typhoid	2	Do.

SURFACE RESERVOIRS.

1	Poor	Good	Good	Good	Unprotected vault	Good	Used on farm	None		
2	do	do		do	Protected vault	do	do	do		

CISTERNS.

1	Fair	Good	Good	Good	Protected vault	Good	Used on farm	None		
2	do	do		do	do	do	do	do		
3	Good	do		Fair	Unprotected vault	do	Butter sold	do		
4	Poor	Fair		do	do	Fair	Used on farm	do		
5	do	Poor		Good	do	Poor	do	do		

TABLE IV.—*Analytical data concerning the water supplies in Minnesota of which an examination was made.*

DUG WELLS.

No.	Physical examination.			Chemical examination.									Bacteriological examination.[a]		
	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli.	
														1 c. c.	100 c. c.
1[b]	0	0	e 1	520	268	0.056	0.006	0.005	37.00	37.0	Tr.	26	580	—	+
2[b]	28	140	e 3	930	830	.34	62.00	.007	.20	115.0	8.00	90	2,550	+	+
3[b]	1	4	ed 2	172	194	.024	.026	.001	1.10	4.0	.90	5	135	—	+
4[b]	4	24	e 2	64	82	.29	.036	Tr.	.30	31.5	.30	20	7,580	+	+
5[b]	1	16	e 2	500	438	.14	.014	.002	22.00	66.0	.10	80	785	—	—
6[b]	1	10	me 1	340	310	.084	.028	.008	6.00	115.0	Tr.	22	......	......	......
7[b]	0	0	e 1	253	228	.032	.016	Tr.	.50	1.0	.20	5	40	—	—
8[b]	0	14	e 2	353	279	.25	.056	.012	11.00	30.0	.70	36	1,050	+	+
9[b]	0	3	e 1	215	210	.024	.012	.00	1.40	.5	.40	......	900	+	+
10[b]	Tr.	11	de 1	407	350	.21	.048	.02	16.00	51.0	Tr.	51	2,200	+	+
11[b]	2	22	em 1	310	279	.34	.067	.07	11.00	73.0	.50	45	89	+	+
12[b]	0	11	e 3	555	411	.088	.016	.002	21.00	74.0	.40	14	2,450	+	+
13[b]	0	17	d 4	740	613	.26	.83	.016	1.60	103.0	.50	74	1,450	+	+
14[b]	0	8	e 3	1,000	385	.25	.036	.008	58.00	175.0	Tr.	41	93	+	+
15[b]	1	11	e 1	1,900	301	.19	.016	.011	145.00	630.0	.60	37	555	+	+
16[b]	3	16	e 1	500	394	.14	.008	.002	6.00	53.0	.80	24	435	+	+
17[b]	0	5	e 2	607	316	.12	.03	.005	45.00	48.5	.10	40	400	+	+
18[b]	......	......	......	378	244	.028	.012	.005	27.00	28.0	.10	20	500	+	+
19[b]	1	4	e 1	278	254	.032	.012	.001	.80	Tr.	.10	14	600	+	+
20[b]	3	28	d 4	500	222	.38	.42	.27	52.00	300.0	.40	61	1,000	+	+
21[b]	4	8	e 2	420	336	.062	.066	.036	14.00	32.0	.30	35	210	+	+
22[c]	0	0	v 3	429	228	.11	.04	.045	30.00	45.0	.05	28	325	+	+
23[b]	0	Tr.	v 1	383	216	.046	.012	.001	5.00	9.0	.40	100	24,300	+	+
24[c]	5	35	v 2	182	378	.192	.006	.00	.00	12.0	1.60	23	1,635	+	+
25[c]	5	10	v 2	830	688	.054	.012	.08	20.00	40.0	.00	51	23,400	+	+
26[c]	15	40	v 2	450	374	.474	.154	.07	35.00	80.0	Tr.	36	2,000	+	+
27[c]	15	10	d 3	443	400	.458	.120	.010	.00	10.0	Tr.	51	10,000	+	+
28[c]	5	20	e 2	895	540	.330	.072	.025	3.50	185.0	.40	20	2,600	+	+
BORED WELLS.															
1[b]	3	12	d 4	3,800	545	0.24	0.092	0.05	1.20	11.0	0.50	39	570	+	+
2[c]	15	20	v 1	265	480	.076	.120	Tr.	.00	.8	2.00	58	495	+	+
3[c]	400	10	e 3	760	540	.256	3.380	.02	.00	85.0	1.20	50	10,000	—	+
4[c]	20	0	e 2	479	312	.710	.200	.003	Tr.	110.0	.00	25	10,000	+	+
5	......	......	......	......	......	......	......	......	......	......	......	......	130	+	+
6	......	......	......	......	......	......	......	......	......	......	......	......	380	+	+
DRILLED WELLS.															
1[b]	4	6	e 1	218	221	0.01	0.012	0.000	0.50	1.5	0.50	7	755	—	+
2[b]	0	7	e 2	800	322	1.20	.01	.007	28.00	63.0	Tr.	19	785	+	+
3[b]	Tr.	4	e 1	470	270	.08	.026	.001	10.00	102.0	.10	10	220	+	+
4[b]	21	10	ed 3	338	388	.07	.15	.015	.15	.5	3.10	26	705	—	+
5[b]	2	0	p 4	393	306	.056	Tr.	.002	9.00	9.5	.10	15	330	+	+
6[b]	1	12	m 2	610	394	.08	.086	.028	6.20	33.5	.20	26	2,210	+	+
7[b]	2	11	m 2	785	354	.092	.068	.45	28.00	77.0	......	35	760	+	+
8[c]	300	5	e 1	286	460	.052	.814	Tr.	.00	8.0	25.00	98	150	—	—
9[c]	5	20	e 1	150	268	.432	1.374	Tr.	.00	100.0	1.20	28	17	—	—
10[c]	0	10	v 2	575	452	.152	.084	.10	15.00	65.0	Tr.	70	540	—	—
11[c]	0	10	e 1	130	224	.086	.700	.004	.30	115.0	Tr.	9	255	—	—
12[c]	50	25	e 1	550	304	.306	.630	.100	3.50	655.0	2.80	40	850	+	+
13[c]	25	20	e 1	205	200	.060	.030	Tr.	.00	2.0	2.80	25	10	—	—

[a] Bacteriological examination by Dr. A. J. Chesley.
[b] Chemical and physical examinations by Mr. M. G. Roberts.
[c] Chemical and physical examinations by Mr. H. A. Whittaker.

TABLE IV.—*Analytical data concerning the water supplies in Minnesota of which an examination was made.*—Continued.

DRIVEN WELLS.

	Physical examination.			Chemical examination.									Bacteriological examination.[a]		
No.	Turbidity.	Color.	Odor at 20° C.	Total hardness.	Alkalinity.	Albuminoid ammonia.	Free ammonia.	Nitrites.	Nitrates.	Chlorin.	Iron.	Free carbonic acid.	Bacteria per cubic centimeter.	Bacillus coli.	
														1 c. c.	100 c. c.
1[b]	.....	32	m 2	303	338	0.038	0.072	0.005	0.02	2.5	1.90	29	160	+	+
	.....	8	md 2	303	341	.18	.10	.003	.02	2.5	6.40	33	80,000	+	+
2[b]	2	22	m 2	250	280	.02	.44	.00	.15	1.0	1.30	3	256	—	+
3[b]	0	0	e 2	310	246	.026	.04	.003	3.80	4.0	.20	15	350	—	—
4[b]	0	0	e 1	560	319	.072	.21	.26	13.00	19.0	.25	24	1,550	+	+
5[b]	18	95	e 1	435	248	.37	.31	.025	2.40	4.0	6.80	20	29	—	—
6[b]	6	48	e 2	445	234	.028	.048	Tr.	Tr.	3.0	2.20	13	58	—	—
7[b]	0	0	e 2	200	236	.02	.004	.00	2.30	3.5	.20	11	170	—	+
8[b]	12	30	em 1	220	218	.04	.01	.003	4.40	6.0	21.00	10	550	—	+
9[b]	0	0	e 1	190	248	.026	.003	.00	.22	Tr.	Tr.	7	33	—	—
10[b]	2	7	e 2	281	260	.010	.002	Tr.	.25	Tr.	.40	35	25	—	—
11[b]	200	4	d 3	2,000	363	.084	1.50	.001	Tr.	3.0	62.00	49	10	—	—
12[b]	3	10	e 1	253	193	.026	.004	Tr.	5.40	3.0	.50	6	10	—	—
13[c]	0	30	e 2	500	412	.444	.022	Tr.	2.50	5.0	.00	45	1,250	—	+
14[c]	0	120	d 2	770	828	2.340	13.400	.220	35.00	165.0	1.20	90	1,153	+	+
15[b]	3	14	md 2	......	175	.024	.006	Tr.	3.40	2.0	1.40	6	65	—	—
16[c]	0	0	e 1	300	200	.060	.022	.001	30.00	22.0	.10	11	45	—	—
17[c]	0	0	v 2	620	260	.036	.030	.020	35.00	14.0	Tr.	14	25	—	+
18[c]	0	0	v 2	190	180	.084	1.260	.002	.30	2.0	Tr.	21	10	—	—
19[c]	15	15	v 1	243	200	.068	.240	Tr.	.00	2.0	1.80	18	10	—	—
SPRINGS.															
1[b]	0	0	m 2	179	176	0.048	0.024	0.009	6.00	3.5	0.05	3	2,200	+	+
2[c]	5	15	v 1	1,110	328	.238	1.050	.033	.00	2,350.0	1.60	52	1,000	+	+
RIVERS.															
1[c]	10	50	v 3	176	140	0.580	0.026	Tr.	1.00	5.0	Tr.	3	1,216	+	+
2[c]	10	50	v 3	176	140	.580	.026	Tr.	1.00	5.0	Tr.	3	1,216	+	+
3[c]	15	25	v 2	176	146	1.084	.390	0.00	0.00	5.0	Tr.	8	10,000	+	+
SURFACE RESERVOIRS.															
1[c]	160	40	v 2	1,530	112	3.014	0.860	Tr.	0.00	4,100.0	8.00	62	2,000	+	+
2[c]	5	30	v 3	457	176	1.346	1.410	0.080	.00	505.0	.00	23	890	+	+
CISTERNS.															
1[c]	0	30	v 1	22	36	0.235	0.260	0.007	0.30	5.0	0.00	3	1,600	+	+
2[c]	5	30	v 1	32	32	.390	.623	.00	.00	10.0	.00	11	1,000	+	+
3[c]	5	20	v 1	30	8	.214	.446	Tr.	.00	10.0	.40	5	1,000	+	+
4[c]	5	55	v 2	40	12	.504	.490	.005	.00	50.0	.00	13	80,000	+	+
5[c]	5	30	v 2	64	36	.560	.042	.00	.00	80.0	Tr.	7	1,000	+	+

[a] Bacteriological examination by Dr. A. J. Chesley.
[b] Chemical and physical examinations by Mr. M. G. Roberts.
[c] Chemical and physical examinations by Mr. H. A. Whittaker.

A review of the foregoing data shows that of the 79 supplies examined 20 furnished water of a satisfactory quality, while 59 were more or less seriously polluted. It must be remembered, however, that, other conditions being similar, bad supplies are of greater interest to the sanitary investigator and are selected for study, as it is these supplies which indicate the dangers to be avoided. Therefore, the percentage of unsanitary supplies is much larger than would be found if examination had been made of all the rural water supplies of any large area. The actual proportion of polluted supplies in rural districts may at present be assumed to be about 35 per cent.[a]

The distinction between good and bad supplies is of course an arbitrary one. In accordance with the modern ideas upon this subject the greatest dependence is placed upon personal inspection of the environment of any supply in question,[b] the bacteriological data being next in importance.

Interpreted in the light of the field observations the bacteriological examination gives the best evidence of actual pollution, in spite of the difficulty of determining the significance of the so-called sewage organism, *Bacillus coli*. The more or less ubiquitous character of this bacillus[c] does not, however, entirely destroy its value as an indicator of pollution. It must be remembered that typhoid fever, popularly the most dreaded disease, is by no means the only one that the water sanitarian is called upon to prevent. The great decrease in death rate, exclusive of deaths from typhoid, which follows the installation of a bacteriologically pure water supply[d] shows the necessity for extending the idea of a polluted water beyond the mere possibility of its serving as the carrier of typhoid bacilli. With the assumption, therefore, that minor and indefinite or undescribed intestinal disturbances play a considerable part in the death rate due to polluted water, that much-discussed organism *Bacillus coli* may still fairly be taken as representing by its presence a more or less objectionable pollution, as it is essentially an intestinal inhabitant, whether of human or other animal origin. The degree of pollution must be determined from the total count of bacteria, supplemented by the chemical analyses, and from the field observations.

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[a] Kellerman, K. F., and Beckwith, T. D. Bacteria of the Dairy Wells in the Vicinity of Washington, D. C., and Their Possible Relation to Typhoid Fever at Washington. Engineering News, vol. 57, No. 6, p. 152. 1907.

[b] Leighton, M. O. The Futility of a Sanitary Water Analysis as a Test of Potability. Biological Studies by the Pupils of W. T. Sedgwick, pp. 36–53. Boston, 1906.

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[c] Dyar, H. G., and Keith, S. C. Notes on Normal Intestinal Bacilli of the Horse and of Certain Other Domestic Animals. Technology Quarterly, vol. 6, pp. 256–257. 1893.

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[d] Hazen, Allen. Purification of Water in America. Transactions of the American Society of Civil Engineers, vol. 54, part D, pp. 131–154. 1905.

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RURAL TYPHOID FEVER.

The vital statistics of the country are even less satisfactory than those of the city, and in spite of the emphasis that has recently been given to the importance of rural typhoid[a] it is at the present time impossible to determine whether typhoid fever is essentially an urban disease, as has been generally supposed, occasionally transmitted into other districts, or whether rural typhoid exists as such, independent of city infection. In the Minnesota studies the origin of many cases was untraceable, perhaps because typhoid fever is a disease carelessly or irregularly reported to the State Board of Health by the attending physicians, and for practical purposes it is necessary for the present to assume that in any rural district typhoid fever may suddenly develop.

During this investigation 23 of the farms examined showed a record of typhoid fever. On 11 of these farms it was found impossible to locate the source of infection, on 2 possible sources were determined, and on 10 farms the data seemed to locate definitely the source of infection. The water supplies furnishing data which more or less definitely located the source of typhoid infection will be briefly noted.

Farm No. 12, under dug well type. One case during 1908, a boy 15 years of age, taken sick July 18. For some weeks before the boy became ill the city of Mankato, Minn., had been suffering from a severe typhoid epidemic, due to an infected city water supply.[b] The boy, who delivered milk in the city, drank water from the city supply on a number of occasions before his illness. He was immediately removed to the city hospital and no other cases developed on the farm.

Farm No. 3 under bored well type. Six cases during the spring of 1908. The first case was brought from Oslo, Minn., where the patient had been employed as a servant in one of the hotels. The secondary cases may have been due to contact or to water pollution.

Farm No. 5 under driven well type. Three cases during 1907; apparently infected in Minneapolis.

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[a] Whipple, G. C. Typhoid Fever, pp. 112–114. New York, 1908.

[b] Established by extensive investigations made by the Minnesota State Board of Health.

Farm No. 12 under driven well type. Two cases during 1908; the first, a girl 16 years old, was taken sick July 14, and the second, a boy 14 years old, was taken sick July 25. Both of the infected people attended a circus at Wadena, Minn., June 27, on which occasion they drank city water, water on the railroad train, and circus lemonade. On July 10 they attended a second circus at Henning and drank water from several sources. The data collected indicate quite clearly that the disease was contracted during attendance at the Wadena circus, June 27.

Farm No. 17 under driven well type. One case during 1907, a man taken sick October 10. September 19 to 21 he had attended a street fair at Anoka, Minn., and drank water from the city drinking fountain. Several cases of typhoid were present in the city of Anoka and were supposed to have been infected by the city supply.[a]

Farm No. 2 under drilled well type. Three cases during 1908; the first two, a man and a woman, taken sick July 7, the third, a woman, taken sick July 17. The well on this place is badly located and receives surface wash from the entire yard. The privy is so located that during heavy rains, which occurred at the period of the year previous to the infection, the surface wash from that direction reaches the well.

RURAL TYPHOID EPIDEMIC FROM THE RED LAKE RIVER.

A small rural epidemic occurred during the investigation in the Red River Valley and included three farms in a sparsely populated region.

Farm No. 13 under driven well type and farm No. 4 under "Rivers." Two cases in 1908; a girl 19 years old, taken sick February 10, and a boy 13 years old, taken sick March 10. The girl had not been away from the farm for at least six weeks preceding her illness and no other cases of typhoid were present in the community. During the winter season until February 25 the water supply was the Red Lake River, which flows near the house. At a point called Huot, several miles up the Red Lake River from this farm (see farms No. 2 under "Rivers" and No. 26 under "Dug wells"), four cases of typhoid occurred during the spring season; the first, a boy 10 years old, taken sick February 15; the second, a man 40 years old, taken sick February 28; the third, a boy 7 years old, taken sick April 19. None of these patients had visited any other district before or after their infection. The other case of this infected group was a man 38 years old who was taken sick April 1. (See farms No. 1 under "Rivers" and No. 26 under "Dug wells.") From February 28 until the date of illness he had remained constantly with his brother. (See farm No. 2 under

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[a] Data furnished by the Minnesota State Board of Health.

"Rivers.") He drank Red Lake River water from November 15 until the date of his illness. This case may be one of contact or of direct infection from the original source, the Red Lake River.

The cities contributing sewage or drainage above the point of infection are St. Hilaire, Red Lake Falls, and Thief River Falls. During the winter season there are lumber camps scattered along the Red Lake River beyond Thief River Falls, and these also might play some part in the pollution. The river also flows through a part of the Red Lake Indian Reservation.

SUMMARY AND CONCLUSIONS.

(1) Both farm and city are suffering from the careless management of rural sanitation.

(2) Previous investigations of rural water supplies have been more or less unsatisfactory, due either to the local or fragmentary character of the investigations or to the use of a single method in studying the supplies in question.

(3) Exhaustive data upon 79 carefully selected and typical rural water supplies show that 20 were good and, usually because of careless or ignorant management, that 59 were polluted.

(4) Of the polluted wells, 11 are so located that even extreme care would not make them safe; 10 are poorly located, but improvements in the protection from surface wash and infiltration would make them safe; 25 are bad only because of poor surface protection and could easily be made safe; 1 is polluted from unknown, probably distant, sources. One spring supply is polluted because of poor surface protection and could easily be made safe. The rivers, surface reservoirs, and cisterns are polluted, and it is doubtful whether satisfactory supplies can be secured for farm use from such sources. Where their use is necessary, water for drinking should be boiled or otherwise disinfected.

(5) During this investigation 23 of the farms examined showed a record of typhoid fever. On 11 of these farms it was found impossible to locate the source of infection, on 2 farms possible sources were determined, while on 10 the data seemed to locate definitely the source of infection. The water supplies upon 5 of these farms were not polluted and the infection was traceable to outside sources; the water supplies of the remaining 18 farms were polluted.

(6) The protection of farm supplies by common-sense methods obvious to anyone who will try to discover the dangers incident to his own water supply would render safe the majority of the farm supplies which are now polluted. Exhaustive studies of rural conditions at the present time, therefore, are warranted only in connection with epidemiological studies.

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